

A survey of ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province

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DECLARATION

I Monwabisi Charles Mesela, hereby declare that the research study titled **Survey of ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in the Western Cape Province** is my own work. All sources cited have been acknowledged through the Harvard method of referencing.

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ABSTRACT

Blood glucose control with intravenous insulin therapy is one of the most frequently used treatment modalities to manage hyperglycaemia in critically ill patients. Almost all critically ill patients admitted in the Intensive Care Unit (ICU) will require blood glucose control to manage stress induced hyperglycaemia. Blood glucose control by means of intravenous insulin therapy is associated with reduced morbidity and mortality rates, which ultimately improves patient care outcomes. Although blood glucose control is beneficial for critically ill patients, however, it is potentially dangerous due to the side effects of insulin therapy, namely hypoglycaemia and hypokalaemia. As ICU professional nurses are responsible for blood glucose control in critically ill patients, it is therefore essential that they have adequate knowledge of blood glucose control measures to ensure patient safety and improve outcomes.

The aim of this study was to determine ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province. The study was non-experimental, descriptive and quantitative in nature. Data was collected by means of an anonymous, self-administered questionnaire in June 2013. Ethical approval to conduct the study was obtained from the University of Cape Town's Health Sciences Faculty Human Research Ethics Committee. Permission to conduct the study in the specific research setting was obtained from the Hospital Senior Medical Services Manager. Descriptive and correlational statistics were used to analyse the data.

The results indicated that the knowledge of ICU professional nurses with regard to blood glucose physiology and blood glucose control in critically ill adult patients was adequate. A positive but minimum correlation was found between the respondents' ages, years of experience of working in an ICU and knowledge of blood glucose physiology and blood glucose control in critically ill adult patients ($r=0.28$). No significant differences were found between ICU qualified and ICU experienced professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients ($p=0.196$). A lack of knowledge was found in aspects relating to the correct identification of the clinical manifestations of hypoglycaemia, the side effects of insulin and insulin compatibility with other medications.

Key words: ICU, professional nurse, knowledge, hyperglycaemia, critically ill, insulin therapy.

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ABBREVIATIONS

AIDS	Acquired immunodeficiency syndrome
CVI	Content validity index
DENOSA	Democratic Nurses' Organisation of South Africa
HIV	Human immunodeficiency virus
ICN	Intensive care nurse
ICNS	Intensive care nursing services
ICNT	Intensive care nursing training
ICU/s	Intensive care unit/s
SA	South Africa
SANC	South African Nursing Council
SPSS	Statistical package for the social services

DEFINITION OF TERMS

Terminology	Definition of terminology
Continuing professional development	Continuing professional development refers to planned post qualification learning which aims at improving nurses' knowledge, skills and competence (Dickerson, 2010:100).
Critically ill patient	Patients with an illness or injury that pose a threat to their lives and requires the patient to have specialised nursing care and monitoring. These types of patients may require mechanical ventilation and complex pharmacotherapy (McFerrin & Martin, 2008:256).
Enrolled nurse	An enrolled nurse is a nurse educated to practice basic nursing care in the manner prescribed and to the stipulated level (Nursing Act, No.33 of 2005, 2005: chap 2, sec 30 (3)).
Gluconeogenesis	The formation of glucose from by the liver from non carbohydrate sources such as amino acids and fats (Hinkle & Cheever, 2014:77).
Hyperglycaemia	Blood glucose level greater than 7.1mmol/l (Hinkle & Cheever, 2014: 1416-1419).
Hypoglycaemia	Blood glucose level below 3.9 mmol/l in non-diabetic patients and less than 4.4 mmol/l in diabetic patients (Hinkle & Cheever, 2014: 1416-1419).
ICU	An abbreviation for intensive care unit. This is a specialised unit in the hospital that provides for the advanced health care needs of critically ill patients (McFerran & Martin, 2008:256).

DEFINITION OF TERMS CONTINUED

Terminology	Definition of terminology
ICU qualified professional nurse	A professional nurse as defined under Section 30 (1) of the new nursing act (Nursing Act, No. 33 of 2005) who has a post graduate qualification in critical care nursing. This person has received specialised training to care for critically ill patients (Nursing Act, No. 33 of 2005. Regulation R212 of 19 February 1997, as amended).
ICU Mentor	A senior ICU qualified professional nurse who guides and support a junior and inexperienced staff member to develop professionally (Meyer et al., 2009:160).
Inotropes	Medication that increases myocardial force of contraction (Hinkle & Cheever, 2014:692).
Insulin resistance	A condition where the body's tissues become less sensitive to insulin, resulting in reduced uptake of glucose by the liver and muscle cells (Vincent et al., 2011:1210).
Mechanical ventilation	The use of an artificial device to assist a patient to breathe (Urden, Stacy & Lough, 2012:322).
Professional nurse	A nurse who is qualified and competent to independently practice comprehensive nursing in the manner prescribed and to the level stipulated and who is capable of assuming responsibility and accountability for such practice (Nursing Act, No. 33 of 2005, 2005 Chapter 2, Sec 30 (1)).
Stress hyperglycaemia	Hyperglycaemia due to the presence of acute illness or disease, surgery or trauma (Hinkle & Cheever, 2014: 1418-1419).

CHAPTER 1: OVERVIEW OF THE STUDY

1.1 Introduction

This chapter provides an overview of the study. It includes the background to the study, the problem statement, the research question, the aim of the study, the study objectives and the significance of the study.

1.2 Background to the study

Hyperglycaemia, coupled with insulin resistance, is a commonly encountered problem in critically ill diabetic and non-diabetic patients (Finney, Zekveld & Elia, 2003:2041; Mibu, Yatabe & Hanazaki, 2012:71; Valentine & Phillips, 2012:332). The prevalence of hyperglycaemia in critically ill patients is difficult to estimate; however, it has been postulated that up to 12% of hospitalised critically ill patients with no previous history of diabetes will develop hyperglycaemia (Kessler, 2009:38). The prevalence of hyperglycaemia in critically ill diabetic patients has been reported to be as high as 70% to 80% (McDonnell & Umpierrez, 2012:176). The causes of hyperglycaemia are multifactorial and may be due to the hypermetabolic state caused by critical illness, surgery or trauma (Vincent et al., 2011:1210). Hyperglycaemia may also develop due to the administration of glucose containing intravenous fluids as well as the administration of enteral and parenteral feeds. The administration of medications, such as adrenaline and corticosteroids, enhances gluconeogenesis, which promotes hyperglycaemia in critically ill patients (Kessler, 2009:38; Magee, 2006:17-18).

Uncontrolled hyperglycaemia predisposes critically ill patients to numerous complications, such as an increased risk of sepsis and multiple organ failure. Combined, these complications often lead to an increased risk of morbidity and mortality (Kanji et al., 2010:43; Van den Berghe et al., 2001:1360). Krinsley (2004:1476) reported a 42.5% mortality in critically ill patients whose mean blood glucose level exceeded 16 mmol/l. All nurses, including Intensive Care Unit (ICU) professional nurses, must have sufficient knowledge of safe blood glucose targets in order to avoid hyperglycaemia and its harmful effects (Kok, 2012:92). Lack of knowledge regarding the dangers associated with hyperglycaemia is a potential barrier in the implementation of safe and cost-effective nursing care practices (Kok, 2012:92).

Intravenous insulin therapy is an effective way of managing hyperglycaemia in critically ill patients (Jacobi et al., 2012:3252; Kanji et al., 2004:807; Kanji et al., 2010:45). The use of

intravenous insulin therapy is associated with benefits such as reduced sepsis, reduced incidence of multiple organ failure and, ultimately, a reduction in morbidity and mortality rates in critically ill patients (Kanji et al., 2004:807; Schultz et al., 2010:77). Van den Berghe et al (2001:1364) reported a 42% mortality reduction in surgical patients who were treated with intensive insulin therapy for blood glucose control. Maintaining normal blood glucose levels in critically ill patients is important, as all bodily functions rely on a homeostatic balance in order to function efficiently (Clement et al., 2004:558-559; Jacobi et al., 2012:3253). The early normalisation of blood glucose levels provides critically ill patients with a better chance of recovery, with fewer complications (Jacobi et al., 2012:3253; Kanji et al., 2004:807). Intensive care professional nurses must be knowledgeable and aware of the importance of commencing intravenous insulin therapy as early as possible to reduce the harmful effects of hyperglycaemia (Nelson, 2011:6). Knowledge of the benefits associated with the early normalisation of blood glucose levels is essential to ensure compliance with evidence based guidelines for blood glucose control in critically ill patients (Correa, et al., 2012:348).

Intravenous insulin therapy for blood glucose control also carries potential risks when administered to critically ill patients (Kavanagh & McCowen, 2010:2543; Van den Berghe et al., 2006:452-458). Hypoglycaemia and hypokalaemia are the most common and potentially life-threatening complications of insulin therapy (Chinnasamy et al., 2011:313-317; Van den Berghe et al., 2006:452-458). According to Finfer et al (2012:1116), the prevalence of insulin induced hypoglycaemia in critically ill patients is high, occurring in up to 40% of critically ill patients who are receiving intravenous insulin therapy. Uncorrected hypoglycaemia may lead to irreversible brain damage (Urden, Stacy & Lough, 2012:481), whereas hypokalaemia may trigger the incidence of life-threatening cardiac arrhythmias (Urden, Stacy & Lough, 2012:168-171). Intensive care unit professional nurses need to be aware of the adverse effects associated with the administration of insulin to all critically ill patients. The scope of practice of a professional nurse (Nursing Act, No. 33 of 2005, Regulation R2598 of 30 November 1984 (c), as amended) emphasises that it is the responsibility of the professional nurse to monitor the patient for untoward reactions that may occur due to the administration of any medication, including high alert medications, such as insulin.

Blood glucose control is commenced routinely on all hyperglycaemic patients admitted in the ICUs. The complications associated with blood glucose control require skilled and knowledgeable professional nurses who are competent to plan and implement nursing care interventions that minimise risks and enhance patient safety (Nelson, 2011:17). It is therefore

essential that all ICU professional nurses caring for these patients have sufficient knowledge of safe blood glucose control measures to ensure optimum care (Nelson, 2011:6).

Intensive care unit nurses working in the ICUs are not all equally experienced, and some may lack the specialised knowledge to manage the complex health care needs of critically ill patients (Perrie, 2006:2). Without such specialised knowledge, the implementation of safe and cost-effective nursing care cannot be assured (Perrie, 2006:2). Whyte, Ward and Eccles (2009:517) stress that a certain degree of knowledge is essential to be able to practice competently as a nurse. Knowledge cannot be assumed to have been attained based on years of experience and education alone, but needs to be re-evaluated frequently to ensure that it remains current (Whyte, Ward & Eccles, 2009:524).

Several local and international studies have investigated ICU nurses' knowledge with regard to various nursing care aspects in ICUs (Gomes, 2010:116; Jansson et al., 2013:219; Perrie et al., 2014:16-17), but only one study was found that investigated ICU professional nurses' knowledge of blood glucose control in critically ill adult patients. No previous study investigating their knowledge of blood glucose physiology and blood glucose control in the Western Cape Province could be found; this underscores the need for this study.

1.3 Problem statement

It is common practice in the ICUs, which were the setting for this research, to commence intravenous insulin therapy on all critically ill patients who develop stress induced hyperglycaemia. Hinkle and Cheever (2014:1418-1419) define stress induced hyperglycaemia as persistently elevated blood glucose level (above 8 mmol/l) due to acute critical illness, surgery or trauma. Intravenous insulin therapy for blood glucose control is beneficial for critically ill patients, as its use is associated with reduced morbidity and mortality (Gunst & Van den Berghe, 2010:160). Krinsley (2004:1476) and Van den Berghe et al (2001:1364) reported a mortality reduction of 42.5% and 42% respectively in hyperglycaemic critically ill patients treated with intravenous insulin therapy; However, intravenous insulin therapy has the potential to cause serious harm and even death if not administered appropriately (Cobaugh et al., 2013:1405). An estimated 18% to 65% of critically ill patients receiving intravenous insulin therapy to manage stress induced hyperglycaemia develop hypoglycaemia (Krinsley et al., 2011:4-5). Hypoglycaemia is a life-threatening complication of insulin therapy, which can cause irreversible brain injury and death (Urden, Stacy & Lough, 2012:481). In view of the life-threatening complications associated with intravenous insulin therapy for blood glucose control, it is thus important that ICU professional nurses caring for these patients have sufficient knowledge to

implement blood glucose control measures that ensure patient safety and improve outcomes (Perrie et al., 2014:14).

Local and international studies report a concern at what appears to be a lack of knowledge among professional nurses working in the intensive care environment in various nursing care activities, including blood glucose control in critically ill patients (Gomes, 2010:116; Jansson et al., 2013:219; Perrie et al., 2014:16-17). The lack of knowledge is directly proportional to unsafe nursing care practices, which may endanger the life of critically ill patients (Perrie et al., 2014:17). As yet, no studies have been found in the literature, with regard to intensive care professional nurses' knowledge of blood glucose physiology and blood glucose control, in a public tertiary hospital, in the Western Cape Province; the extent or degree of their knowledge has not been studied so far.

1.4 Research question

Are ICU professional nurses, working in the ICUs of a public tertiary hospital in the Western Cape Province, South Africa sufficiently knowledgeable of blood glucose physiology and blood glucose control in critically ill adult patients?

1.5 Research aim

The aim of this study was to determine ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

1.6 The research objectives

The objectives of the study were:

- To design and validate an instrument to determine ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.
- To quantify and describe ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.
- To determine if there is any correlation between age, ICU qualification versus ICU experience as well as years of experience working in ICU and ICU professional

nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

1.7 Significance of the study

It is envisaged that the results of this study will assist Nurse Educators, Operational Nurse Managers and ICU Clinicians in designing effective and appropriate educational programmes for professional nurses with regard to blood glucose control in critically ill adult patients. The results may also be used as part of a needs analysis prior to the implementation of an in-service training programme for ICU professional nurses, focusing specifically on blood glucose control in critically ill adult patients. The study will further contribute to the body of nursing literature on blood glucose control in critically ill adult patients.

1.8 Overview of the methodology

A non-experimental, quantitative, descriptive and correlational design was utilised in this study. The study population comprised 102 ICU professional nurses from a public tertiary hospital in the Western Cape Province. A survey, using a self-administered, anonymous questionnaire, was used to collect data. Data was analysed in consultation with a biostatistician. SPSS version 21 and Excel, and descriptive and correlational statistics, were used to analyse the data.

1.9 Validity and reliability

Validation of the questionnaire was achieved in consultation with two ICU qualified nurse educators from a nursing college in the Western Cape Province. The nurse educators were asked to determine the content, construct and face validity index of the questionnaire, based on the model as proposed by Lynn (1986:382). Two ICU qualified and two non-ICU qualified professional nurses who are experts in critical care nursing were asked to pilot test the questionnaire on two different occasions to ensure reliability. The pre-testers were asked to complete the questionnaire and make comments regarding the clarity of the questions, their difficulty and the relevance of the questions to the study.

1.10 Ethical considerations

The researcher adhered to the ethical principles of research as stipulated in the Declaration of Helsinki (World Medical Association, 2013:1-8) and as mandated by the Democratic Nursing Organisation of South Africa (DENOSA, 2005:2.1-2.4) to protect the rights of the

respondents. Ethical clearance was obtained from the University of Cape Town's Health Sciences Faculty Human Research Ethics Committee (HREC REF: 621/2012) and the Ethics Committee of the public tertiary hospital, where the research took place.

1.11 Summary

Blood glucose control with intravenous insulin therapy is effective in managing and preventing hyperglycaemia in critically ill patients; but if critically ill patients are to benefit effectively from such measures, the ICU professional nurses who care for them need to possess adequate knowledge. Adequate knowledge cannot be assumed to be in place, however; it must be regularly evaluated.

In this chapter, the study background, the problem statement, the research question, aims and objectives, the study significance and an overview of the methodology have been presented. Chapter 2 reviews the literature relevant to the study. In Chapter 3, the study design and methods are described. In Chapter 4, the results of the study are presented. Chapter 5 discusses and summarises the results. Lastly, Chapter 6 provides the recommendations, limitations and conclusions of this study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Hyperglycaemia is common in most critically ill diabetic and non-diabetic patients admitted to the critical care environment (Donahey & Folse, 2013:1; Gunst & Van den Berghe, 2010:157). Before 2001, hyperglycaemia was thought to be a beneficial physiological response to critical illness or trauma (Gunst & Van den Berghe, 2010:157; Van den Berghe et al., 2001:1359). This belief resulted in prolonged periods of rarely treated hyperglycaemia in critically ill patients (Gunst & Van den Berghe, 2010:157; Van den Berghe et al., 2001:1359). Subsequent studies, however, revealed that hyperglycaemia is actually not beneficial but harmful to critically ill patients (Duncan et al., 2010:867; Falciglia et al., 2009:3001-3009; Van den Berghe et al., 2001:1359). Retrospective analyses of data identified a strong association between uncontrolled high blood glucose levels and increased morbidity and mortality rates among critically ill patients (Duncan et al., 2010:867; Krinsley et al., 2013:13).

Intensive care unit professional nurses play a vital role in blood glucose control in critically ill patients, as they are at the patient's bedside 24 hours a day (Chant et al., 2012:275). Effective blood glucose control requires ICU professional nurses who have a wide knowledge base of hyperglycaemia, its causes, the implications of inadequate management and the correct management principles, in order to be able to provide optimal care (Kok, 2012:92). Without sufficient knowledge, ICU professional nurses cannot be expected to render high quality, safe and cost-effective nursing care to critically ill patients (Kok, 2012:92; Perrie et al., 2014:14).

A local study in Gauteng, South Africa (SA), has shown that ICU professional nurses lack adequate knowledge of blood glucose control in critically ill patients (Perrie et al., 2014:17). Knowledge deficits regarding blood glucose control may hamper the recovery and well-being of critically ill patients and may have a negative impact on nursing care rendered (Perrie et al., 2014:17). Lack of knowledge is also a barrier to the implementation of evidence based care (Perrie et al., 2014:17).

In this chapter, the literature is reviewed and discussed under the following headings:

- The causes of hyperglycaemia in critically ill patients.
- The deleterious or harmful effects of hyperglycaemia in critically ill patients.
- The effects of intravenous insulin on blood glucose control in critically ill patients.

- The status of intensive care nursing in SA.
- Intensive care nursing training (ICNT) in SA.
- Continuing professional development in the ICU setting.
- Knowledge levels of ICU nurses in the ICUs.
- The knowledge gap

2.2 Literature search strategy

The literature search was conducted in English. The search time frame was set from the beginning of the year 2000 to 2014. The search engine **EBSCO** host was used to access full text electronic journals from sites such as **MEDLINE** via **PubMed**, **CINAHL**, **SCIENCE DIRECT**, **GOOGLE** and **GOOGLE SCHOLAR**. Randomised controlled trials, clinical reviews and retrospective analyses that evaluated blood glucose control in critically ill patients were included. The search strategy also involved hand searching of journals and critical care medical and surgical textbooks. References of articles and books were used to identify and search for relevant primary sources. The following key words were used to search for relevant data: ICU nurses AND knowledge of AND blood glucose AND control AND critically ill AND adult patients.

2.3 The causes of hyperglycaemia in critically ill patients

It has been reported that up to 12% of non-diabetic and 80% of diabetic critically ill patients admitted to ICUs develop stress induced hyperglycaemia (Donahey & Folse, 2013:1; Kavanagh & McCowen, 2010:2540; Kessler, 2009:38). The causes of stress induced hyperglycaemia are multifactorial and may include the following, though they are not limited to these, as indicated by Kessler (2009:38-39) and Urden, Stacy and Lough (2012:481).

- Acute injury, such as myocardial infarction, cerebrovascular accident, trauma, surgery and sepsis.
- Elevation of counter-regulatory hormones, such as glucocorticoids, glucagon, cytokines and other inflammatory mediators.
- Pre-existing diabetes mellitus and increased insulin resistance by the tissues.
- Iatrogenic factors, such as the administration of glucose containing intravenous fluids, enteral feeds and total parenteral nutrition.

- The administration of medications, such as adrenaline, that enhances gluconeogenesis.

Under such conditions, hyperglycaemia and glucose toxicity are highly likely to occur; this contributes to an 18-fold increase in morbidity and mortality in critically ill patients (Kessler, 2009:39; McDonnell & Umpierrez, 2012:177-178). It is therefore important that ICU professional nurses are aware of and knowledgeable about the causes of hyperglycaemia in critically ill patients, as they are often responsible for administering the fluids and the medication that contribute to the development of hyperglycaemia (Kessler, 2009:38-39).

2.4 The deleterious (harmful) effects of hyperglycaemia in critically ill patients

Hyperglycaemia has been acknowledged as a predisposing factor in the development of life-threatening complications in critically ill patients (Bogun & Inzucchi, 2013:724; Griesdale et al., 2009:821; Park, 2013:385-390). Studies in critical care medicine revealed that hyperglycaemia occurring during acute medical or surgical illness is not an adaptive physiological or benign condition, but that it is rather a marker of poor clinical outcome and mortality (Duncan et al., 2010:867; Falciglia et al., 2009:3001-3009; Van den Berghe et al., 2001:1359).

Stress induced hyperglycaemia, in patients with and without diabetes, is harmful and may give rise to numerous complications (Duncan et al., 2010:867; Falciglia et al., 2009:3001-3009). Elevated blood glucose levels are toxic to the peripheral nerves and increase the risk for polyneuropathy (weakness, numbness of hands and feet, weakness or numbness of the muscles of the body). Polyneuropathy can also cause temporary paralysis of the muscles involved in breathing, which results in delays in weaning and extubation from mechanical ventilation (Duncan et al., 2010:867; Falciglia et al., 2009:3001-3009).

Hyperglycaemia also causes neutrophil dysfunction, which impairs immunity and thus results in an increased risk for infection and delayed wound healing (Donahey & Folse, 2013:2). Furnary and Wu (2006:25) found hyperglycaemia to be independently associated with a 3-4 fold increase in deep sternal wound sepsis in cardiac surgery patients. Persistent hyperglycaemia is known to inhibit the release of insulin by the β cells of the pancreas, resulting in a state of glucose toxicity. A prolonged state of glucose toxicity contributes to endovascular damage, which in turn leads to tissue hypoperfusion and subsequent multiple organ failure (Kessler, 2009:39). Combined, such complications lead to an increase in morbidity and mortality in critically ill patients (Corathers & Falciglia, 2011:278-279; Donahey & Folse, 2013:2; Gunst & Van den Berghe, 2010:157-158).

2.5 The effects of intravenous insulin therapy on blood glucose control in critically ill patients

Intravenous insulin therapy has been identified as the treatment of choice to manage hyperglycaemia in critically ill patients (Jacobi et al., 2012:3253; Kavanagh & McCowen, 2010:2541). Blood glucose control with intravenous insulin therapy is associated with reduced incidence of morbidity and mortality and leads to improved clinical outcomes in critically ill patients (Donahey & Folsie, 2013:4; Gunst & Van den Berghe, 2010:160). According to Furnary and Wu (2006:25), the early normalisation of elevated blood glucose levels with intravenous insulin therapy reduces the incidence of deep sternal wound sepsis in cardiac surgery patients by 77%. Intravenous insulin therapy also has anti-inflammatory properties, which assist in the prevention of intracellular glucose toxicity and intravascular injury. Insulin inhibits intravascular lipolysis and platelet aggregation and by so doing prevents tissue hypoperfusion (Corathers & Falciglia, 2011:270; Jacobi et al., 2012:3253; McDonnell & Umpierrez, 2012:187).

Despite these benefits, however, insulin therapy has the potential to cause serious harm and even death, if not administered appropriately (Cobaugh et al., 2013:1405). Hypoglycaemia is a serious complication of insulin therapy that can result in severe neurological injury (Jacobi et al., 2012:3257; McDonnell & Umpierrez, 2012:187). As stated by Krinsley (2011:4-5), 18% to 65% critically ill hyperglycaemic patients treated with intravenous insulin therapy develop hypoglycaemia. Clinical manifestations that may suggest hypoglycaemia include the following: diaphoresis, tachycardia, hypotension, restlessness and confusion. The clinical manifestations of hypoglycaemia may not be easily recognised in critically ill patients who are pharmacologically sedated or paralysed. Sustained and unrecognised hypoglycaemia may significantly increase the risk for irreversible brain injury and even death (Jacobi et al., 2012:3257; Sauer & Van Horn, 2009:97; Turner, 2007:27-28).

Guidelines published by Dellinger et al (2013:193) and Jacobi et al (2012:3257) recommend that blood glucose be monitored every one to two hours while the patient is receiving intravenous insulin to identify hypoglycaemia early. The same recommendations guide the ICU professional nurse to stop the insulin infusion immediately upon the recognition of clinical signs and symptoms suggestive of hypoglycaemia and to administer 50% glucose intravenously. It is important that all ICU professional nurses are fully aware of and adhere to these recommendations to prevent unintended harm to critically ill patients (Jacobi et al., 2012:3257; Turner, 2007:25-30).

Hypokalaemia is yet another potential complication of intravenous insulin therapy (Vincent et al., 2011:863). Uncorrected hypokalaemia perpetuates the development of life-threatening

cardiac arrhythmias, for example, atrial fibrillation and ventricular fibrillation, which may result in cardiac arrest and instant death (Vincent et al., 2011:863). Life-threatening hypokalaemia is corrected with intravenous potassium administered slowly, at a rate not exceeding 20 mmol/h (millimoles per hour) to avoid subsequent hyperkalaemia, lethal cardiac arrhythmias and unintended death (Urden, Stacy & Lough, 2012:169).

According to Turner (2007:27) and Lee et al (2013:191), it is necessary that all nurses including ICU professional nurses have adequate knowledge to be able to assess, recognise and manage patients who are at risk of developing hypoglycaemia and hypokalaemia due to insulin administration. Monitoring the blood glucose and potassium levels of critically ill patients falls within the scope of practice of ICU professional nurses; however, ICU professional nurses also require a good knowledge base to be able to interpret and act on the results yielded by these tests (Turner, 2007:27).

A study conducted in Singapore has shown that nurses and other health care professionals lack adequate knowledge of insulin and its side effects (Lee et al., 2013:190-191). Knowledge deficits regarding insulin administration pose a safety risk for critically ill patients, as insulin is regarded as a high alert medication with the potential to cause severe harm to patients (Lee et al., 2013:190-191). The study identified a need for the improvement of insulin related knowledge among health care professionals in order to avoid harm to critically ill patients.

In summary, hyperglycaemia is an unwanted consequence of critical illness. Uncontrolled hyperglycaemia is no longer regarded as a benign condition associated with critical illness, but is viewed as a precursor for morbidity and mortality, leading to poor patient care outcomes. Insulin therapy has been identified as the preferred method for blood glucose control in critically ill patients, as its use is linked to improved patient care outcomes. Effective blood glucose control requires knowledgeable nursing staff that is up to date with the most recent literature and evidence based guidelines on blood glucose control in critically ill patients. This facilitates the delivery of high quality evidence based nursing care that enhances patient safety in the ICU; however, such knowledge needs to be evaluated frequently to ensure that it remains current.

2.6 The status of intensive care nursing in South Africa

In SA, Intensive Care Nursing Services (ICNS) are offered by the private and public healthcare sectors. The public sector caters for approximately 80% of the population and is mainly funded by taxpayers' money, whereas the private sector caters for less than 20% of the population who have medical insurance (De Beer, Brysiewicz & Bhengu, 2011:6-7). The

majority of patients admitted to ICUs in SA are males who are victims of trauma, such as motor vehicle accidents, gunshots and stabbings (De Beer, Brysiewicz & Bhengu, 2011:6-7). Other reasons for ICU admissions are medically related, and include sepsis, metabolic conditions, drug overdose, infectious diseases, gynaecological problems and post-surgical interventions (De Beer, Brysiewicz & Bhengu, 2011:6-7).

The HIV/AIDS pandemic is also having an impact on intensive care services in SA. Of the world's 35.3 million HIV-infected people, 6.4 million are in SA (UNAIDS, 2013:4). Such patients often require prolonged stays in ICUs, increasing the strain on the services and further depleting limited resources (De Beer, Brysiewicz & Bhengu, 2011:6-7).

In addition to the disease burden, there is a critical shortage of adequately trained and experienced nurses to staff the ICUs in SA (Pillinger, 2011:8). Due to the staff shortages, both public and private sector hospitals often utilise agency nurses to staff the ICUs (Matlakala, Bezuidenhout & Botha, 2014:2). Of concern is that agency nurses often display a lack of commitment and that their work is not always up to the standards required to deliver quality patient care (De Beer, Brysiewicz & Bhengu, 2011:6-7).

The public and private sector ICUs also make use of sub-professionals, such as enrolled nurses (who have received only two-year training) to take care of the complex health care needs of critically ill patients (Matlakala, Bezuidenhout & Botha, 2014:2). The risk associated with this practice is that the enrolled nurses are inexperienced and not sufficiently trained for these conditions (De Beer, Brysiewicz & Bhengu, 2011:6-7; Matlakala, Bezuidenhout & Botha, 2014:2-7). Intensive care nursing has become very complex due to the severity of critical illness, the complexity of the treatment modalities and the technology required. Employing unqualified and inexperienced nursing staff to care for critically ill patients is not a desirable long-term solution (Perrie, 2006:19).

The loss of experienced and qualified health care professionals also contributes to a shortage of ICU professional nurses in the public and private sector hospitals of SA (Pillinger, 2011:8). This 'brain drain' could be attributed to multiple factors, including inadequate salaries, limited career opportunities, poor nursing leadership, the poor public image of nursing, the huge workload as a result of insufficient staff, the poor working conditions, and a lack of safety and security in the workplace (Pillinger, 2011:8).

Owing to the shortage of ICU qualified professional nurses, the private and public sector health care system often has to rely on newly qualified, less experienced professional and enrolled nurses to nurse critically ill patients (Matlakala, Bezuidenhout & Botha, 2014:4). Comprehensive pre-registration professional nurse programmes focus on primary health care and general ward nursing care, but not on critical care nursing, which is considered a

specialty area. Thus, comprehensive professional nurses and enrolled nurses are not equipped to take care of the health care needs of critically ill patients, without adequate further training, support and supervision, and may therefore pose a risk to patient safety (Matlakala, Bezuidenhout & Botha, 2014:4).

In view of the severity and complexity of critical illness and treatment modalities, including the employment of less qualified and inexperienced nursing staff, it is necessary to evaluate the knowledge of all nurses working in the ICU environment to ensure safe nursing care practices (Perrie, 2006:18).

2.7 Intensive care nursing training in South Africa

Intensive care nursing training (ICNT) was officially established in SA in 1966 as a post-basic qualification (De Beer, Brysiewicz & Bhengu, 2011:6-7). ICNT programs are offered to professional nurses at public and private sector hospitals at university or college level. The South African Nursing Council (SANC) regulates ICNT and prescribes the legal, ethical and professional responsibilities of this postgraduate qualification.

Intensive care nursing education programmes build upon initial generalist pre-registration nursing education. The competencies required in the critical care course have been developed to demonstrate achievement in both theoretical and clinical learning in the following areas: specialist clinical practice, care and programme management, clinical practice leadership and clinical practice development (Nursing Act, No. 50 of 1978. Regulation R212 of 19 February 1997, as amended).

2.8 Continuing professional development

Continuing professional development refers to planned post qualification learning, which aims to improve nurses' knowledge, skills and competence (Dickerson, 2010:100). The goal of continuing professional development is to promote personal and professional growth through lifelong learning, develop and maintain professional competence, enhance professional practice, and support staff in achieving career goals (Dickerson, 2010:100; Richards & Potgieter, 2010:44). Efficient, cost-effective and quality nursing care is only possible, if the knowledge of nursing staff is continuously updated to remain current (Skees, 2010:104).

In view of the ever increasing burden of disease and rising patient acuity, nursing has become more stressful and challenging. Nurses, therefore, are required to remain competent and up to date with the latest developments in patient care (Richards & Potgieter, 2010:43).

Continuing professional development is one way of assisting nurses to manage complex and challenging health care problems, which they may encounter in their daily practice (Chappell and Drenkard, 2010:239). By means of continuing professional development, nurses' skills are improved, allowing them to advance to more complex levels of competence (Cooper, 2009:501). It has also been linked to increased staff satisfaction and good quality patient care (Jaradeh & Hamdeh, 2010:314). According to Richards and Potgieter (2010:44), however, nurses may encounter barriers that prohibit them from developing professionally. Night duty, staff shortages, heavy workload, and personal commitments all create barriers to continuing professional development. In view of the importance of such ongoing education, it is important that health care managers assist nurses to overcome these obstacles (Cooper, 2009:502; Richards & Potgieter, 2010:44-45).

2.9 Knowledge levels of ICU nurses in ICUs: The evidence

The *Oxford Paperback Dictionary* (2009:517) defines knowledge as "information and awareness gained through experience or education." Perrie (2006:30-33) states that knowledge encompasses practical and theoretical knowledge. Practical knowledge is that gained from experience, while theoretical knowledge is that gained from learning. Intensive care nurses (ICNs) rely on both theoretical and practical knowledge in their daily practice to ensure safe and competent nursing care. As stated by Huggins (2004:40), knowledge is "knowing and understanding", whereas skill involves "doing." ICNs apply knowledge and skills simultaneously. Huggins (2004:40) emphasises that "without knowledge of why you are performing skills, you are unable to perform them competently" and that "to perform skills without knowledge is unsafe".

The ICU is a dynamic environment, which requires ICU professional nurses to have up-to-date knowledge that allows them to manage the complex and specialised health care needs of critically ill patients correctly (Elliot, Aitken & Chaboyer, 2012:4-8). For this to happen, however, ICU nurses need to be appropriately trained and knowledgeable with respect to the nursing care they are required to provide.

A number of studies have reported that ICU professional nurses lack adequate knowledge to manage the complex health care needs of critically ill patients (Chinnasamy et al., 2011:313-317; Gomes, 2010:46-48; Jansson et al., 2013:219; Perrie et al., 2014:14-18; Trepp, Wille & Reinhart, 2010:370-375). Such a lack of knowledge may be a barrier to the implementation of safe and effective nursing care. Poor knowledge is also directly proportional to poor nursing care practices and increased risk for critically ill patients (Chinnasamy et al.,

2011:313-317; Gomes, 2010:46-48; Jansson et al., 2013:219; Trepp, Wille & Reinhart 2010:370-375).

Intensive care unit nurses are expected to render quality nursing care to critically ill patients, particularly since nurses are legally accountable for their acts and omissions (Perrie et al., 2014:14). To render such quality care, ICU nurses ought to have the appropriate knowledge, skills and experience to be able to assess and effectively respond to the complex needs of critically ill patients (Matlakala, Bezuidenhout & Botha, 2014:7). Iranmanesh, Raflei and Ameri (2011:460) emphasise that adequate knowledge is an indispensable foundation for good patient care, and that a lack of knowledge may lead to errors that may negatively affect care.

A study conducted by Windsor (2005:131) in SA reported a lack of knowledge among ICU nurses with regard to ventilator waveform interpretation. The study results revealed that, of 111 respondents in the study, only 15 achieved the set competency score of 70%. The results of the study, although not recent, and not relevant to blood glucose control in critically ill patients, would seem to indicate that there is a concern about ICU nurses' knowledge and their application of such knowledge. This study was, however, limited to three selected private hospitals and is therefore not generalisable.

The lack of knowledge within the ICU environment is confirmed further by the results of a study conducted by Labeau et al (2010:16-24). Examining ICU nurses' knowledge of evidence based guidelines for the prevention of surgical site infection, Labeau et al's study echoes the view that a knowledge deficit exists among nurses working in the ICU environment. This reiterates the importance of on-going educational programs to improve ICU nurses' knowledge and enhance their competence. The study sample consisted of ICU nurses attending an annual critical care society congress. This convenience sample may have introduced some bias, as it is likely to have included more motivated respondents. The results are also difficult to extrapolate to the South African context, as the study was done in Europe and the respective health care systems differ significantly.

In Gauteng Province (SA), a study by Gomes (2010:116) also identified poor knowledge among ICU nurses with regard to evidence based guidelines for the prevention of ventilator associated pneumonia. The ICUs of one public sector hospital and two private sector hospitals in Gauteng were the setting for the study. The average score obtained by the majority of the nurses was 45%, which was well below the competency indicator of 70%. The main findings of the study indicated that ICU nurses lacked knowledge with regard to the evidence based recommendations to prevent ventilator associated pneumonia. In addition, the study found no correlation between the ICU nurses' age and years of experience

on the one hand, and their knowledge of evidence based guidelines for the prevention of ventilator associated pneumonia on the other hand. A limitation of this study is that it was done in three hospitals in one province, therefore, the results cannot be generalised to other provinces. The sample size was also small (81 respondents) and the reliability measures were not explicitly stated, thus making it difficult to assess the quality and accuracy of the results.

The findings by Gomes (2010:116) are supported by a recent study conducted by Jansson et al (2013:216-227) in Finland. Jansson et al (2013:216-227) explored, through a cross-sectional survey, critical care nurses' knowledge of, adherence to and barriers towards evidence based guidelines for the prevention of ventilator associated pneumonia. In their study, the main self-reported barrier towards adherence to evidence based guidelines on the prevention of ventilator associated pneumonia was a lack of skills and knowledge. This study was limited by the fact that the adherence measures and barriers were self-reported.

Perrie et al (2014:14-18) identified poor knowledge of blood glucose control, pain management and weaning from mechanical ventilation among ICU qualified and non-ICU qualified professional nurses in Gauteng Province. The average score obtained by the respondents was 48.7%, which was well below the desired 70% competency indicator. Furthermore, Perrie et al (2014:14-18) found no correlation between the ICU nurses' years of experience and their knowledge of blood glucose control, pain management and weaning from mechanical ventilation. The results of this study indicate that, despite specialist training, ICU qualified professional nurses did not appear to be more knowledgeable than nurses who only had experience in ICU. The Cronbach alpha coefficient of the data collection instrument was 0.7, which was below the acceptable reliability coefficient of 0.8 to 0.9. This may prevent any firm conclusions being drawn from the results. The methodological strength of this study is that it included an equal number of ICU qualified and ICU experienced professional nurses, which ensures a well representative sample. This limited study is not generalisable, however, but it may nonetheless have implications for the assumed knowledge basis of ICU nurses in other provinces.

The poor knowledge of nurses and doctors has been noted as a concern in other settings as well, as reported by Trepp et al (2010:370-375) in a ward-based study in Switzerland. In this study, the diabetes related knowledge of doctors and nurses was discovered to be low due to insufficient continuing education in the area of diabetes management. Nurses' knowledge of diabetes was comparable to that of student nurses. Despite the identified lack of knowledge, the nurses in the study appeared confident about their diabetes related knowledge prior to the study. The study demonstrates the importance of continuing education in order to ensure the provision of quality nursing care that is based on adequate knowledge.

The results of the study are not generalisable to other settings, as the study was done in a single centre. The reliability and internal consistency of the questionnaire was satisfactory, as indicated by the Cronbach alpha coefficient of 0.75, which strengthens the credibility of the results.

A study conducted by Chinnasamy et al (2011:315-317) reported a lack of knowledge among ward nurses in the management of hypoglycaemia in a tertiary hospital in London. Of the 100 ward nurses who participated in the study, only 28% could identify the common symptoms of hypoglycaemia. Only 73% of the hypoglycaemic events that occurred in the ward were identified during routine testing. The study recommended that further training in this regard was needed. Validity and reliability measures and limitations were not reported in this paper, but relevant and meaningful suggestions were made for future research.

2.10 Knowledge gap

It is apparent from the literature that a lack of knowledge exists among nurses working in ICUs and general wards. This lack of knowledge may be a barrier to the implementation of evidence based, safe and cost-effective nursing care. Poor knowledge quite simply decreases the quality of nursing care. Most of the studies reviewed in this chapter were conducted in Europe and United States of America, and the results therefore may have limited generalisability to the South African context, as the health care systems differ. Although not all the studies looked specifically at nurses' knowledge of blood glucose control in critically ill patients, they did highlight a general problem of a lack of knowledge among nurses in the ICU environment.

Only one South African study identified a lack of knowledge of blood glucose control in critically ill patients among ICU professional nurses. No studies were found investigating ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill patients in the Western Cape Province. As a result, it can be hypothesised that knowledge gaps remain in this regard.

2.11 Summary

Critically ill patients are at an increased risk for morbidity and mortality due to prolonged periods of uncontrolled hyperglycaemia. Intravenous insulin therapy has been identified as the treatment of choice to control hyperglycaemia and prevent unwanted harmful effects in critically ill patients. Maintaining blood glucose levels within normal ranges by means of insulin therapy has been associated with improved outcomes for critically ill patients; however, intravenous insulin therapy is also linked to adverse effects, such as

hypoglycaemia and hypokalaemia. These adverse effects are potentially harmful, especially if they are not recognised, managed and prevented in time. SA faces a shortage of ICU qualified professional nurses to take care of the complex health care needs of critically ill patients. The shortage of adequately trained and experienced ICU professional nurses puts critically ill patients at risk of being cared for by untrained and insufficiently knowledgeable staff. The resulting patient care errors may harm critically ill patients. Studies revealed that nurses working in ICUs often lack adequate knowledge to enable them to care for critically ill patients. The current study, based in the Western Cape Province, thus adds to the body of knowledge about ICU professional nurses' knowledge with reference to blood glucose control in critically ill patients.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter outlines the research design and methodology, and moreover describes the research setting, the development and validation of the research instrument, the data collection process used, the population, the sampling, and the relevant ethical considerations. The aim of the study was to determine ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province. The objectives of the study were:

- To design and validate an instrument to determine ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province;
- To quantify and describe ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province;
- To determine if there is any correlation between age, ICU qualification versus ICU experience as well as years of experience working in ICU and ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

3.2 Study design

A non-experimental, quantitative, descriptive and correlational design was utilised in this study. A quantitative approach was selected, because the researcher wanted to gather objective and measurable data that would assist him in answering the research question (Polit & Beck, 2014:8). In non-experimental quantitative research, the study is done in the natural setting without manipulating the independent variable (Newell & Burnard, 2011:204). The phenomenon is observed as it occurs naturally, and the role of the researcher is that of an observer (Polit & Beck, 2014:159). A non-experimental, quantitative approach was found to be suitable for this study, as it occurs in a natural setting the ICU, and as there is no manipulation of variables. The study is descriptive in nature, as the researcher aims to describe ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. Descriptive designs are best suited for studies that seek

to describe phenomena in detail and that aim to gather information that would shed light on a particular issue (Brink, Van der Walt & Van Rensburg, 2012:112; Schmidt & Brown, 2009:148).

The purpose of a correlational design is to describe relationships between variables (Newell & Burnard, 2011:209). A correlational design was deemed to be suitable for the study because one objective was to determine whether there was any correlation between several demographic variables (namely, age, ICU qualification, ICU experience and years of experience working in an ICU and ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients).

3.3 Research setting

The ICUs of two public tertiary hospitals in the Western Cape Province were the initial setting for this study. However, despite being granted ethical permission to conduct research at both hospitals, access to the second hospital was not possible. This was due to logistical difficulties with respect to the access requirements set by the Nursing Manager of the relevant hospital. The researcher was not permitted to enter the ICUs in order to distribute the questionnaires. This made it impossible to make contact with the nurses in the units, to obtain information and answers to questions. After consulting with the study supervisor, and having considered the accessible nurse population in the first hospital, it was decided to amend the study protocol and to conduct the study in the first hospital only.

This study was thus conducted in the adult ICUs in a public tertiary hospital in the Western Cape Province. The hospital receives referred critically ill patients from the surrounding health care facilities and referrals from the rest of the country and beyond sub-Saharan Africa. It is an academic hospital that offers both undergraduate and postgraduate training for all health care professionals from SA and abroad. The hospital has 975 beds, of which 68 are allocated to ICU (Eight in General Surgery: Eight in the respiratory unit, Six in spinal injury unit, Six in cardiothoracic, Six coronary care, 12 neurosurgery and high care, Seven in transplant unit, Three in the isolation unit, Six in haematology, Three in obstetrics and Three in orthopaedic high care. This study was limited to the adult ICUs and excluded the neonatal and obstetrics ICUs. Blood glucose control is a well-established practice within all the ICUs in the research setting.

3.4 Research method

The study was conducted in two phases, namely:

Phase one

- Design and validation of the questionnaire.

Phase two

- Quantification and description of ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients.
- Correlation between age, ICU qualification versus ICU experience as well as years of experience working in ICU and ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

3.5 Phase one: Development and validation of the questionnaire

3.5.1 Questionnaire design and format

Quantitative research often makes use of measuring instruments such as questionnaires to collect objective data that would assist in answering the research question (De Vos et al., 2011:171). A self-administered questionnaire was selected as the best method for data collection, as the intention of the study was to gather factual and quantifiable information, with regard to ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. Questionnaires are quick and cost-effective to administer and the data collected is easy to code and analyse (Polit & Beck, 2014:186).

A literature review was conducted to guide the researcher in compiling the questions, which were included in the questionnaire. This was done to ensure that only questions relevant to the research topic were included. The questionnaire was constructed in English, which is the official language of communication and used in all patient related documentation in the research setting. A closed format design was followed in developing the questionnaire. This meant that the questions permitted only prescribed answers (Polit & Beck, 2014:184). The length of the questionnaire was four pages, which were printed back to back in a booklet format, for easy reading. Each questionnaire was individually numbered to prevent duplication of questionnaires and to ensure the anonymity of the respondents.

The questionnaire comprised 23 closed ended, multiple choice type questions, eight of which were true or false type questions (Appendix G). Respondents were forced to choose one correct answer from a list of two to four possible answers. The answers to each question were marked alphabetically from (a) to (d) and included the option "I don't know", to prevent respondents from guessing. Closed ended questions were chosen, since they are

quicker to answer. The questionnaire was divided into two sections: in section one, questions one to four comprised demographic information (age, training, experience and continuing professional development). In section two, questions one to 23 dealt with knowledge of blood glucose physiology and blood glucose control in critically ill patients. The questions in section two were structured as follows: (See Table 1 below):

- Questions one to nine dealt with basic knowledge relating to blood glucose physiology.
- Questions 10 to 23 referred to knowledge of blood glucose control in critically ill adult patients

Table 1: Grouping of questions in the questionnaire

SECTION	QUESTION	DESCRIPTION	LINK TO REFERENCES USED
1	1-4	Demographics.	Not applicable.
2	1-9	Knowledge of blood glucose physiology in critically ill adult patients	Van den Berghe et al (2001:1359-1367). Magee (2006:17-26). Kessler (2009:38-43). Finfer et al (2009:1284-1285).
2	10-23	Knowledge of blood glucose control in critically ill adult patients.	Finney et al (2003:2041-2047). Kanji et al (2004:804-810). Van den Berghe et al (2006:449-461). Kanji et al (2010:46-47). Turner (2007:25-30). Jacobi et al (2012:3251-3271). Dellinger et al (2013:165-228).

Three sources were used to compile the questionnaire:

- Evidence based recommendations made by the South African Critical Care Nurses Forum, for the administration of continuous insulin infusion for blood glucose control in critically ill adult patients (Turner, 2007:25-30).
- The review of the available literature on blood glucose physiology and blood glucose control in critically ill adult patients.
- The Scope of Practice pertaining to professional nurses (Nursing Act, No. 33 of 2005. Regulation R2598 of 30 November 1984, as amended) as well as the regulation relating to clinical nursing, specifically with regard to critical care (Nursing Act, No.33 of 2005. Regulation R212 of 19 February 1997, as amended).

The South African Critical Care Nurses Forum, which falls within the Critical Care Society of Southern Africa, formulated recommendations on the use of intravenous insulin for blood glucose control in critically ill adult patients (Turner, 2007:25-30). These recommendations were based on evidence obtained from the literature and input from the medical and nursing experts in the field of critical care. They included information on what solutions to use when mixing an insulin infusion, how often to remix the insulin infusion, the measuring of blood glucose, the monitoring for and detection of side-effects and the role of protocols in blood glucose control in critically ill adult patients. These recommendations were incorporated in the questions posed in the questionnaire.

The review of the literature suggested useful questions to be included in the questionnaire. The work done by Van den Berghe et al (2001:1359-1367) and Finfer et al (2009:1284-1285) was used to formulate the questions on the physiological changes that occur due to critical illness, including the harmful effects of uncontrolled hyperglycaemia in critically ill adult patients. The results of studies conducted by Finney et al (2003:2041-2047); Kanji et al (2004:804-810); Kanji et al (2010:46-47) and Van den Berghe et al (2006:449-461) contributed to the formulation of questions on hyperglycaemia and the role of intravenous insulin therapy for blood glucose control in critically ill adult patients. Clinical reviews conducted by Magee (2006:17-26) and Kessler (2009:38-43) were used to develop questions about the iatrogenic factors that perpetuate hyperglycaemia in critically ill adult patients. The recommendations and guidelines developed by Dellinger et al (2013:165-228); Jacobi et al (2012:3251-3271) and Turner (2007:25-30) were adhered to in the formulation of questions relating to practice.

Blood glucose control and monitoring forms part of the Scope of Practice of a professional nurse, as stipulated under the Nursing Act, No. 33 of 2005. Regulation R2598 of 30 November 1984, as amended, specifically in sections (a) to (c) and sections (h) to (s). All professional nurses are expected to have adequate knowledge of blood glucose control in order to render quality nursing care to all patients.

3.5.2 Validity and reliability of the data collection instrument

Validity and reliability are essential to establish in a newly developed research instrument (Brink, Van der Walt & Van Rensburg, 2012:171).

3.5.2.1 Content validity

Validation of a newly developed research instrument is important to ensure reliability (Lynn, 1986:382; Polit & Beck, 2014:205). Brink, van der Walt and van Rensburg (2012:166)

emphasise the importance of presenting a newly developed questionnaire to a group of experts to validate its content. Two ICU Nurse Educators from the Western Cape College of Nursing were approached and asked to evaluate the content validity of the newly developed questionnaire. A non-probability purposive sampling method was used to select the nurse educators who validated the questionnaire. Purposive sampling ensures that those with the required knowledge to achieve the research goals are sampled to participate in the study (Bryman, 2012:418).

The experts were thus asked to establish the content validity index (CVI) of each question using a four-point ordinal rating scale (Lynn, 1986:382-384; Perrie, 2006:44; Polit & Beck, 2014:205). Questions were rated as follows: 1= irrelevant, 2= relevant but unimportant, 3= relevant and important, 4= relevant and very important. A question that received a rating of less than three was considered as unimportant and disregarded. Only those questions with a rating of three or four were considered to be sufficiently important and content valid. The expert panel members were also asked to evaluate the questionnaire with regard to the following: the layout, format and quality of printing, and whether the questions were easy or difficult to read and understand. They were also requested to determine how long the questionnaire would take to complete and whether the use of multiple choice questions was appropriate.

Content validity was enhanced further through the literature review. A thorough literature review is essential to ensuring that the content of the questionnaire captures the full content domain (Polit & Beck, 2014:205). The aim of this was to confirm that the questions asked in the questionnaire did indeed address current issues, as outlined in the literature on blood glucose physiology and blood glucose control in critically ill adult patients.

Face validity was evaluated by the expert panel members described above. Brink, van der Walt and van Rensburg (2012:166) state that face validity is based on the judgement made by experts in the field. The expert panel members were asked to assess whether the questions included in the questionnaire were appropriate and relevant to the topic of blood glucose physiology and blood glucose control in critically ill adult patients.

3.5.2.2 Feedback from the ICU nurse educators

The first expert panel member rated the content and face validity of the data collection instrument as relevant and very important. In addition, the expert panel member advised the researcher to consider using the term “normal ranges” rather than “lower ranges” in Question 13, a recommendation with which the researcher complied. Suggestions were also made to improve the layout and readability of the questionnaire, with which the researcher complied.

The second expert panel member rated the content and face validity as relevant and very important, except for Question two. Question two enquired about the function of insulin in the body. The expert panel member felt that the question was unimportant; however, the researcher considered the question as very important in the context of the study, and therefore retained it in the questionnaire.

3.5.2.3 Reliability

Following the establishment of content and face validity, the reliability of the questionnaire was evaluated. The instrument was pilot tested, using the test-retest reliability method (Leedy & Ormord, 2013:90-91; Polit & Beck, 2014:202). Two ICU qualified and two ICU experienced professional nurses were asked to pilot test the questionnaire on two different occasions. Results obtained from the test-retest procedure were compared by the researcher and were found to be similar, and the reliability was thus judged to be acceptable. Kumar (2011:181) states that, “when you collect the same set of information more than once using the same instrument and get the same or similar results under the same or similar conditions, the instrument is considered reliable.”

3.5.3 Pilot testing the questionnaire

Pilot testing the questionnaire was conducted with two ICU qualified and two ICU experienced professional nurses. The pilot testers were asked to complete the questionnaire and to comment on the clarity of the questions, how long it took to complete, and to identify difficult and or irrelevant questions (Gerrish & Lacey, 2010:378). Pilot testing the questionnaire enabled the researcher to ensure that all the questions were clearly worded and easy to understand. Testing the questionnaire further strengthened its content and face validity (De Vos et al., 2011:195). The professional nurses who pilot tested the questionnaire were excluded from participating in the main study.

Feedback from the pilot testers indicated that the questions were indeed clearly worded and easy to understand. The pilot testers were also of the opinion that the questions were relevant to the topic of blood glucose control in critically ill adult patients and nursing. Questionnaire completion time was determined to be between 15 to 30 minutes. The researcher was advised to add the option “I do not know” in the answers to the multiple choice questions, to prevent people from guessing. Based on their feedback, minor adjustments were made.

3.5.4 Ethical considerations

Ethical measures, as set out by DENOSA (2005:2.1-2.4), were adhered to during the development and validation of the questionnaire. The researcher also adhered to the ethical principles as stipulated in the Declaration of Helsinki (World Medical Association, 2013:1-8). Written informed consent was obtained from the expert panel members and the pilot testers of the questionnaire. Confidentiality and anonymity was ensured throughout the study. The questionnaire did not make provision for including the names of the respondents; instead numbers were used to identify the questionnaires. The input and views from the expert panel members and the pilot testers were treated confidentially.

3.6 Phase two: The main study

The objectives for this phase were:

- To quantify and describe ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province;
- To determine if there is any correlation between age, ICU qualification, ICU experience as well as years of experience working in ICU and ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

3.6.1 Population

The target population is defined by Brink, van der Walt and van Rensburg (2012:131) as all the people who are of interest to the researcher. In this study, the target population comprised 112 ICU professional nurses in a public tertiary hospital in the Western Cape Province. LoBiondo-Wood and Haber (2010:222) state that it is often impossible to collect data from the entire target population due to time constraints, costs and accessibility issues. Instead, therefore, the researcher can make use of an accessible population that meets the inclusion criteria of the target population (LoBiondo-Wood & Haber, 2010:222). Results obtained in relation to the accessible population are then generalised back to the target population (Brink, van der Walt & van Rensburg, 2012:131). The accessible population, as identified through the ICU staff duty roster, comprised 102 ICU professional nurses who were on duty at the time of data collection. The accessible population was thus limited to ICU professional nurses who were on duty and working in the ICUs of a public tertiary hospital in the Western Cape Province. Sixty-four of the respondents were ICU experienced and had no additional

qualification in ICU nursing. Thirty-eight were ICU experienced and held an additional qualification in ICU nursing.

3.6.2 Sample and sampling method

A sample is a subset of the population, whereas sampling is the process of selecting a portion of the population that will represent the target population (Polit & Beck, 2014:177). The sample in this study consisted of consenting ICU professional nurses who were available and on duty at the time of data collection. Professional nurses who happened to be on their day off, sick or on leave were thus excluded from the sample. A non-probability, convenience sampling method was used to select the sample from the accessible population. The sample size was determined using the Centre for Disease Control and Prevention (CDC) Epi Info 7 Stat Calc (CDC Epi info user guide, 2010:216-223). The target population size was set at 112, the expected frequency was set at 50% and the confidence limit was set at 6%, with a confidence level of 95%. The sample size was calculated to be 80 respondents; however, due to the population size, the biostatistician recommended that the entire accessible population of 102 ICU professional nurses be included, as they were all available at the time of data collection. For this study, therefore, the accessible population was included; sampling was not done.

3.6.2.1 Inclusion criteria

As described above, all ICU professional nurses working in an adult ICU of a public tertiary hospital, in the Western Cape Province were included in the study.

3.6.2.2 Exclusion criteria

All professional nurses working in the ICU who were off duty, ill, absent or on vacation during the data collection period were excluded. The professional nurses who had pre-tested the questionnaire were also excluded from the study.

3.6.3 Data collection method

Data collection commenced once approval was granted by the Senior Medical Services Manager of the hospital where the study was conducted (Appendix J). Written informed consent was obtained from the respondents who agreed to participate (Appendix B). The respondents were reassured in writing, that participation in the study was voluntary and that they had the right to refuse or withdraw from the study at any time, should they wish to do so. Confidentiality and anonymity was further ensured, as respondents were asked not to

write their name or staff employee number on the questionnaire. Consenting respondents were instructed to keep the signed consent form separate from the completed questionnaire to enhance confidentiality and ensure anonymity.

Arrangements to enter the ten ICUs were made with the ICU Nurse Manager and the Operational Nurse Managers of each ICU. The researcher hand-delivered the questionnaires to the respondents who were on duty at the time of data collection. Each respondent received a single numbered questionnaire, which had to be completed individually. It was not always possible for the researcher to be present while the respondents were completing the questionnaires. In these cases, the researcher relied on the Operational Manager or ICU shift leader to supervise the respondents, while they completed the questionnaires on their own.

Data collection took place over a period of two weeks, from the 15th June until the 30th June 2013. Both day and night shifts were covered, by including staff on opposite shifts. The researcher spent approximately two to four hours a day, on day and night shifts, collecting the data. The respondents completed the questionnaires during their lunch break, during visiting times and when the ICUs were not busy. Minimal disruption was ensured by timing data collection to take place during the times that were usually less busy (i.e. by avoiding scheduled patient care activities or doctors' rounds), so as to ensure that patient care was not compromised.

The questionnaires took approximately 15 to 30 minutes to complete. Each respondent was instructed to place the completed questionnaire in an unmarked sealed envelope. These envelopes were then placed in a sealed box, which was stationed in each ICU. The completed questionnaires were collected in person by myself.

3.6.4 Data management

One hundred and two questionnaires were distributed and the same number was returned. Counting and checking of the questionnaires, for completeness, illegibility and ambiguity of answers, was done by the researcher. Six missing values were identified from the different questionnaires. Three respondents did not answer Questions two, seven and eight while another three respondents did not attempt Questions 14, 15 and 23. After consultation with the statistician, questionnaires with missing data were included in the data analysis. The missing data was categorised as incorrect responses. Each correct answer was allocated one mark, and a zero mark was assigned for an incorrect response. A total number of correct responses were obtained for each respondent and a percentage calculated. For questions on blood glucose physiology, a score of 50-59% indicated adequate knowledge, scores between 60-69% indicated above average knowledge, and scores above 70% were an indication of

excellent knowledge. Any score below 50% was an indication of inadequate knowledge. For questions on blood glucose control, a score of 60-69% indicated adequate knowledge, and scores above 70% indicated excellent knowledge. Any score below 60% was an indication of inadequate knowledge.

Codes were assigned to the responses to the multiple choice questions and the demographic information, such as ICU qualified and ICU experienced. The coded data was transcribed onto an Excel spread sheet and double-checked by the researcher for consistency, errors and outliers, before being sent to the biostatistician.

The data set was backed up on the researcher's personal computer, and the completed questionnaires stored in a lockable cabinet in the researcher's office to protect the data. Access to the data was limited to the researcher, the supervisors and the biostatistician to ensure confidentiality and anonymity.

3.6.5 Data analysis

Data was analysed with the assistance of a bio-statistician, using SPSS version 21. Descriptive statistics were used to analyse and describe the demographic data: age, ICU qualification versus ICU experience and years of experience working in ICU. Descriptive statistics were also used to describe ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. Means, standard deviations and confidence intervals were used to summarise the level and extent of respondents' knowledge. Results from the analysed data are summarised and presented in the next chapter (Chapter 4: Data Analysis and Presentation of Results).

The Pearson correlation coefficient (r), Spearman correlation coefficient and linear regression analysis were used to correlate ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients according to several variables (age and years of experience working in an ICU). The Pearson correlation coefficient ranges between -1 and 1. The stronger the correlation, the closer to 1 is the r value. The weaker the correlation, the closer to -1 is the r value (Kim & Mallory, 2014:152). The ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients was correlated to ICU qualification and ICU experience using the Chi-square test. The significance level was set at $\alpha = 0.05$ and the confidence interval at 95%.

3.6.6 Ethical considerations

Ethical principles are guidelines for making moral decisions that must be obeyed and adhered to by all researchers (Pera & Van Tonder, 2011:53). The researcher adhered to the following ethical principles, as stipulated in the Declaration of Helsinki (World Medical Association, 2013:1-8), as well as the ethical measures set out by DENOSA (2005:2.1-2.4).

3.6.6.1 Autonomy

Autonomy refers to the individual's democratic right to make an independent decision about his/her actions and choices, provided these choices and actions do not infringe on the rights of others (Pera & van Tonder, 2011:53). The respondents' right to self-determination was maintained and respected throughout the study. Participation in the study was on a voluntary basis, and informed written consent was obtained from the respondents before they enrolled in the study. The respondents moreover had the right to refuse or withdraw from the study at any stage, without incurring any penalties. The respondents were informed that they would not benefit financially from participating in the study. A small incentive in the form of a chocolate bar was offered to all ICU professional nurses who participated in the study. This incentive was given, as many of the ICU professional nurses completed the questionnaire during their tea and lunch breaks. It was also given to those who did not meet the study inclusion criteria, for example, the enrolled nurses.

3.6.6.2 Non-maleficence and Beneficence

The principle of beneficence ensures that no harm is done to individuals when they participate in research (Beauchamp & Childress, 2013:150-151). The researcher has a duty to protect the respondents from incurring any form of harm as a result of participating in the research study (Polit & Beck, 2014:83). In this study, the principles of non-maleficence and beneficence were ensured and applied as follows:

- The respondents were informed, in writing, that they could withdraw from the study at any time should they wish to do so, without incurring any sanctions.
- The completed questionnaires data were kept confidential and stored in a lockable cabinet.
- The respondents were requested not to write any personal details on the questionnaire to ensure that they remained anonymous.

3.6.6.3 Right to privacy and confidentiality

The completed questionnaires were placed in a sealed envelope and returned to the researcher. The questionnaires will be kept for the prescribed period of three years and thereafter destroyed.

3.6.6.4 Justice

The principle of justice implies treating the research respondents with fairness and equality (Pera & van Tonder, 2011:55). In addition, the principle of justice maintains that the researcher has the responsibility to distribute the benefits and burdens associated with the research study equally among the research respondents (Polit & Beck, 2014:85). All the respondents were treated fairly, with courtesy and respect. No preferential treatment was given.

3.6.6.5 Informed consent

Hulley et al (2013:212-213) state that informed consent is only attained when the respondents have received sufficient and explicit information about the proposed research study. Respondents need to be fully aware of the risks and benefits associated with the study and to have the mental capacity to give consent voluntarily. Respondents received an information letter with detailed information regarding the study before signing the consent form (Appendix A). The information letter was written in English, which is the official language of communication and used in all patient related documentation in the particular research setting. Consent was obtained in writing from the respondents prior to data collection (Appendix B). The researcher emphasised that consent was voluntary and none of the respondents were compelled to participate in the study.

3.7 Summary

A non-experimental quantitative, descriptive and correlational design was utilised in this study. The research study was conducted in two phases, namely: Phase one - the development and validation of the questionnaire, and Phase two - data collection by means of a self-administered anonymous questionnaire. Data was analysed using descriptive and inferential statistics. Ethical considerations were adhered to.

The next chapter will discuss the data analysis and present the results obtained.

CHAPTER 4: DATA ANALYSIS AND PRESENTATION OF RESULTS

4.1 Introduction

In this chapter, the results of the data analysis are presented. The demographic information pertaining to the ICU nurses who participated is described in Section 4.2.1. In the following sections the correlational analysis is presented.

4.2 Analysis of demographic data

4.2.1 Age groups

Seven age groups were identified for comparison and analysis. The majority of the respondents were found in the age group of 40 to 55 years (n=69). The age group between 30 to 39 years was the least representative (n=33) (see Figure 1 below).

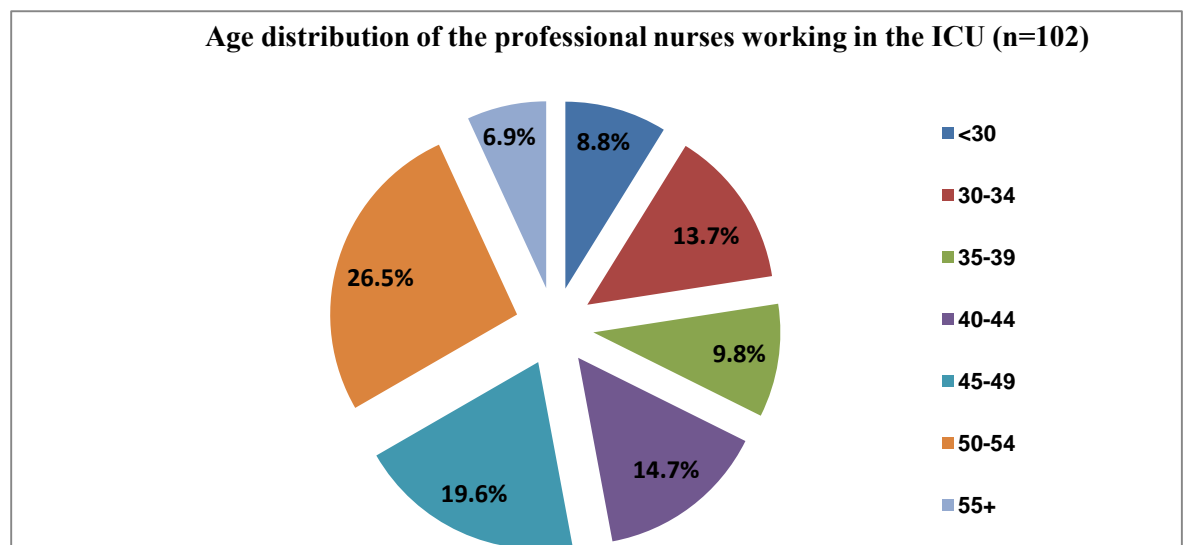


Figure 1: Age distribution of the professional nurses working in the ICU (n=102)

4.2.2 ICU qualification versus ICU experience

The respondents were asked to indicate whether they were ICU qualified or ICU experienced. Figure 2 shows that only 38 (37.3%) ICU professional nurses working in the ICU were ICU qualified, whereas the majority 64 (63.7%) were ICU experienced.

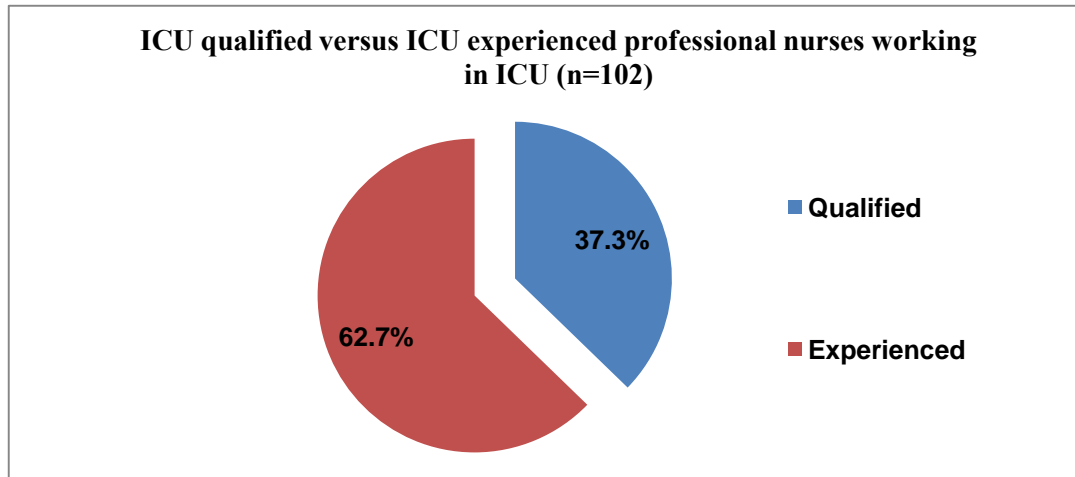


Figure 2: ICU qualified versus ICU experienced professional nurses working in an ICU (n=102)

4.2.3 Years of experience working in an ICU

The respondents' years of experience working in an ICU varied from less than five to at least 30 years. The majority 53 (51.9%) had been working in the ICU for less than four to nine years. The most experienced respondents, 49 (48.03%), had between 10 and 30 years of experience working in an ICU (see Figure 3 below).

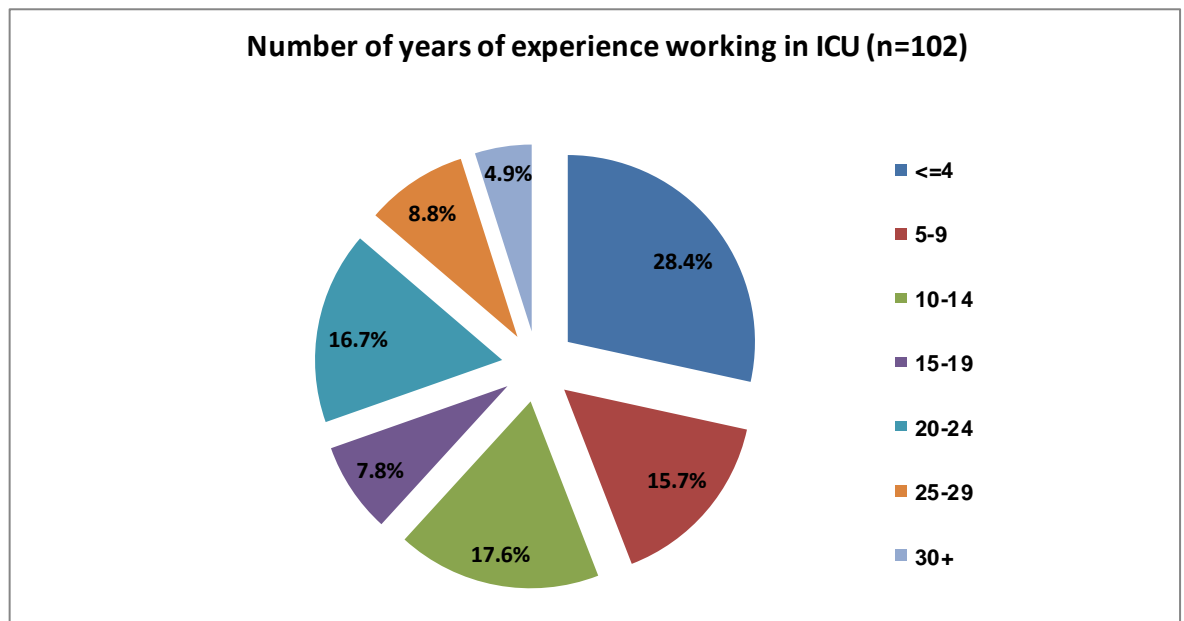


Figure 3: Number of years of experience working in an ICU (n=102)

4.2.4 Years of experience working as a general professional nurse

Years of experience as a general professional nurse (i.e. not ICU nursing) ranged from less than 10 years to at least 35 years. The majority, 53 (51.9%), had 10-29 years of experience working as a general professional nurse, 26 (25.49%) had more than 30 years of experience, and 23 (22.5%) had less than 10 years of experience (see Figure 4).

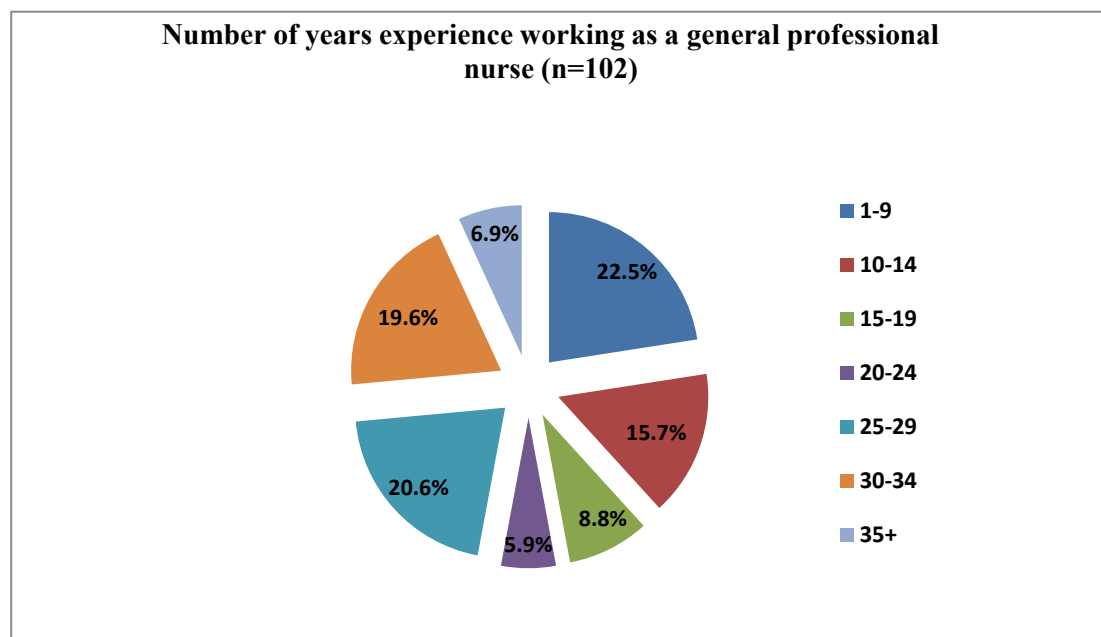


Figure 4: Number of years of experience working as a general professional nurse (n=102)

4.2.5 Continuing professional development

The respondents were given four options to indicate how they ensured their own continuing professional development. The options were 1= “Attend ICU ward rounds”; 2= “Read peer reviewed journal”; 3= “Attend academic ward rounds”; 4= “Attend critical care society meetings”; 5= “None”. Respondents were allowed to select more than one option. One of the respondents did not answer Option 5, resulting in a total of 101 respondents who replied to this question. Because they could choose more than one option, the total number of responses does not add up to 101 or 100%. The following can be observed from Figure 5:

The majority of the ICU professional nurses 82 (81.2%) stated that they attended academic ward rounds. This was above the 75th percentile. The second most selected option shows that more than the 5th percentile of nurses (36%) read peer reviewed journals. Almost the same number of nurses attended either ICU congresses (25%) or critical care society meetings

(26%) respectively. Only ten (9.9%) of the nurses did not engage in any form of continuing professional development process.

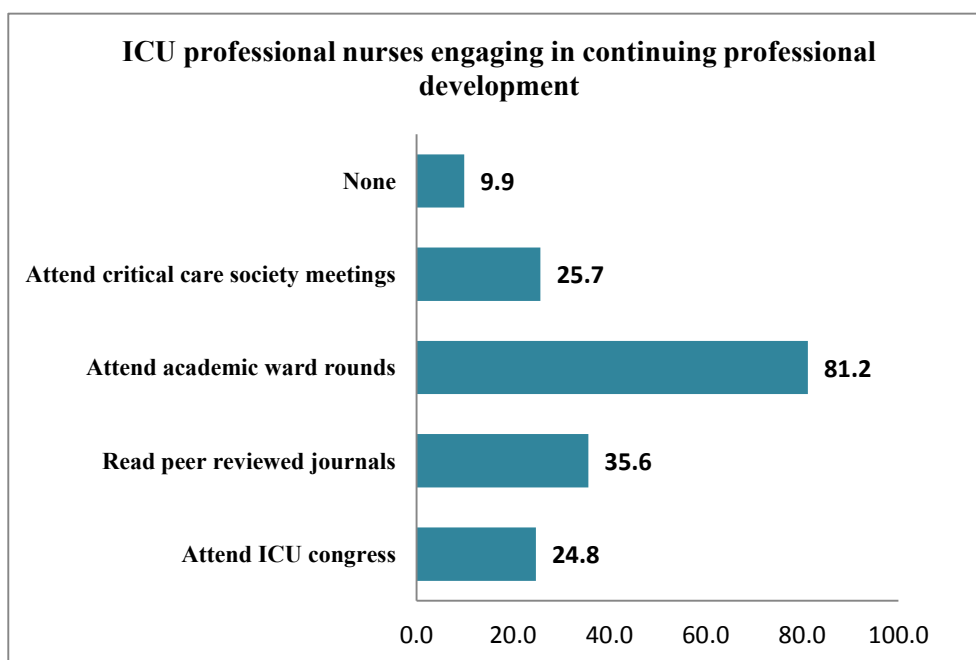


Figure 5: ICU professional nurses engaging in continuing professional development

4.3 Analysis of ICU professional nurses' knowledge

The analysis of the responses given by the ICU professional nurses to the questions that assessed their knowledge level is presented in Table 2 on page 36 (blood glucose physiology competency levels) and Table 3 on page 37 & 38 (glucose control competency levels) below.

4.3.1 Knowledge of blood glucose physiology

All the questions were answered, with the exception of Questions 2, 7 and 8, each of which was not answered by one respondent. As all of them exceeded the 50% competency level (with the results ranging from 70.6% to 100%), it was thus found that their knowledge of blood glucose physiology was sufficient (see Table 2 below).

Table 2: ICU professional nurses' knowledge of blood glucose physiology in critically ill adult patients

Assessment Question	Total Respondents	No. correct responses	No. incorrect responses	No. did not respond	% correct responses	% incorrect responses
Q1: Where in the body is insulin produced?	102	102			100.0%	0.0%
Q2: What is the function of insulin in the body?	101	73	28	1	72.3%	27.7%
Q3: What is the function of glucose in the body?	102	72	30		70.6%	29.4%
Q4: What is the normal blood glucose level in the body?	102	72	30		70.6%	29.4%
Q5: A blood glucose level less than 4 mmol/l is known as?	102	84	18		82.4%	17.6%
Q6: A blood glucose level that is greater than 8 mmol/l is known as?	102	97	5		95.1%	4.9%
Q7: Hyperglycaemia in critically ill patients is usually due to?	101	98	3	1	97.0%	3.0%
Q8: What other factors may contribute to the development of hyperglycaemia in the critically ill?	101	95	6	1	94.1%	5.9%
Q9: Which of the following drugs, if administered, may contribute to the development of hyperglycaemia in critically ill patients?	102	94	8		92.2%	7.8%

4.3.2 Knowledge of blood glucose control

The performance of the respondents with regard to the 14 questions that assessed their knowledge of blood glucose control in critically ill adult patients is presented in Table 3 below. Three (2.94%) of the 102 respondents did not attempt to answer Questions 15, 16 and 23. Whilst the ICU professional nurses demonstrated sufficient knowledge in ten of the 14 questions (Questions 10, 11, 12, 13, 14, 15, 18, 19, 21 and 23), they demonstrated a lack of

knowledge with regard to the remaining four questions (Questions 16, 17, 20 and 22). Most of the respondents achieved the desired 60% competency level for this section of the questionnaire.

Table 3: ICU professional nurses' knowledge of blood glucose control in critically ill adult patients

Assessment Question	Total Respondents	No. correct responses	No. incorrect responses	No. did not respond	% correct responses	% incorrect responses
Q10: Uncontrolled hyperglycaemia in critically ill patients is associated with an increased risk for morbidity and mortality.	102	69	33		67.6%	32.4%
Q11: Intravenous insulin therapy is an effective way of controlling blood glucose in the critically ill.	102	94	8		92.2%	7.8%
Q12: Blood glucose control using intravenous insulin therapy is associated with improved clinical outcomes for critically ill patients.	102	100	2		98.0%	2.0%
Q13: Maintaining blood glucose levels in the lower ranges of 4.1 mmol/l to 6.1 mmol/l with intravenous insulin therapy is associated with reduced morbidity and mortality rates for critically ill patients.	102	93	9		91.2%	8.8%
Q14: Hypoglycaemia is a serious and life-threatening complication of insulin therapy.	101	98	3	1	97.0%	3.0%
Q15: Which of the following statements is correct regarding the management of hypoglycaemia in a patient who is on an insulin infusion?	101	100	1	1	99.0%	1.0%

Table 3: Continued

Assessment Question	Total Respondents	No. correct responses	No. incorrect responses	No. did not respond	% correct responses	% incorrect responses
Q15: Which of the following statements is correct regarding the management of hypoglycaemia in a patient who is on an insulin infusion?	101	100	1	1	99.0%	1.0%
Q16: Clinical manifestations of hypoglycaemia in critically ill patients may include the following EXCEPT	102	19	83		18.6%	81.4%
Q17: Hypokalaemia is a potentially life threatening complication of insulin therapy	102	58	44		56.9%	43.1%
Q18: Life threatening hypokalaemia in the critically ill is managed as follows	102	74	28		72.5%	27.5%
Q18: Life threatening hypokalaemia in the critically ill is managed as follows	102	74	28		72.5%	27.5%
Q19: Insulin infusions should ideally be given via a dedicated intravenous line	102	93	9		91.2%	8.8%
Q20: Insulin infusions may be given via the same line as other compatible medications	102	42	60		41.2%	58.8%
Q21: Which carrier solution (diluent) should be used when mixing insulin infusion	102	71	31		69.6%	30.4%
Q22: Insulin infusions should be remixed...	102	19	83		18.6%	81.4%
Q23: How often should blood glucose be monitored while patient is receiving an insulin infusion?	101	98	3	1	97.0%	3.0%

4.3.3 Correlations

This section looks at the correlations between various demographic variables (namely, age, ICU qualification versus ICU experience and years of experience working in ICU and knowledge of blood glucose physiology and blood glucose control in critically ill adult patients).

Linear regression analysis was utilised to determine these correlations. Scatterplots were drawn to depict the correlations (see Figures 6 and 7 on pages 40 and 42). The correlation between ICU qualified and ICU experienced professional nurses was measured using the chi-square test presented in Table 4 on page 41.

4.3.3.1 Correlation between age and ICU professional nurses' knowledge of blood glucose physiology and blood glucose control

The regression line is used to understand the correlation between age and ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. The scatterplot drawn on page 40 implies that a linear relationship exists between these two variables, as the scores are scattered around the line towards the positive axis. The Pearson correlation coefficient (r) is 0.28. This suggests a positive but minimal relationship between the different variables and the level or extent of their knowledge. Stated differently, it seems that the maturity of the ICU professional nurses had a positive influence on their performance in the test.

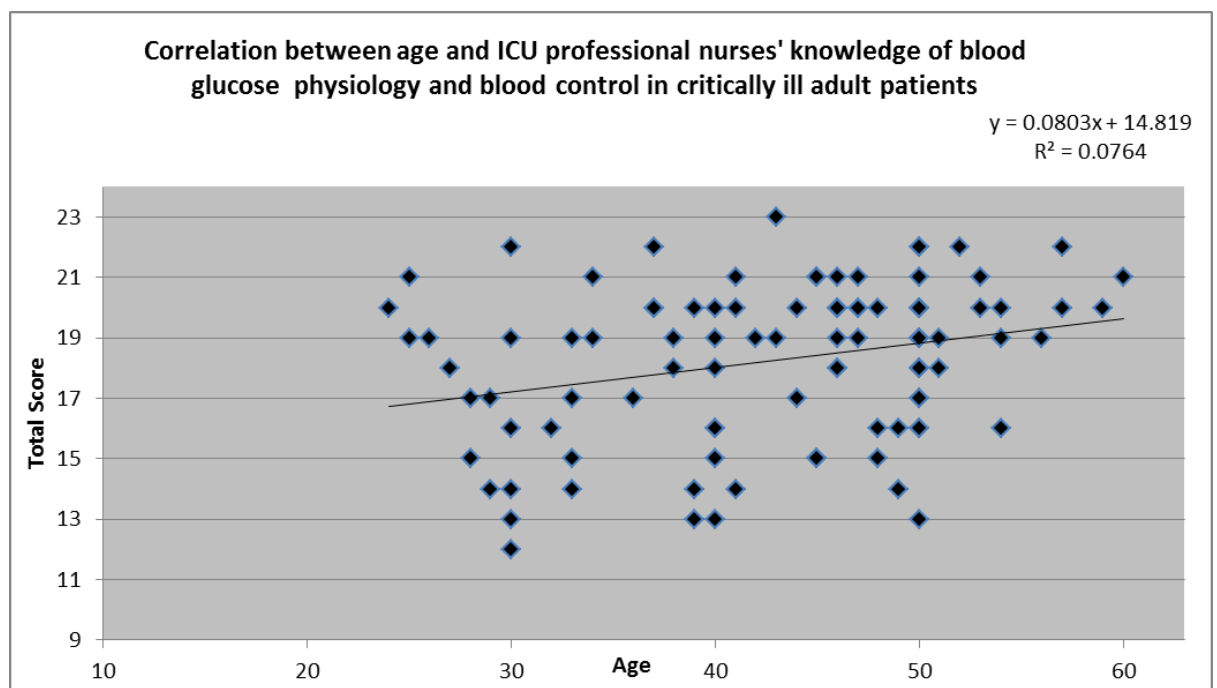


Figure 6: Correlation between age and ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients

4.3.3.2 Correlation between ICU qualification versus ICU experience and knowledge of blood glucose physiology and blood glucose control

The categories of the ICU professional nurses are indicated in the first two rows of Table 6 below. The remaining rows present the statistics that measure the correlation between being ICU qualification and ICU experience, and knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. Thirty-eight (37.3%) ICU professional nurses were ICU qualified, whereas 64 (62.7%) were ICU experienced (i.e. not ICU qualified). Of the 38 ICU qualified professional nurses, one failed the test. This is an insignificant 2.6% of the total number of ICU qualified professional nurses.

All of the ICU experienced professional nurses achieved the set competency level. The Pearson correlation coefficient (r) and the Spearman correlation coefficient are negative (-0.129), suggesting a weak correlation between the knowledge of ICU qualified versus ICU experienced professional nurses. No significant differences were found between the two categories. This is further confirmed by the significance level of ($p=0.196 > 0.05$), suggesting that evidence based on the current results is not sufficient to suggest that an ICU-related qualification had increased their knowledge in this regard.

Table 4: Correlation between ICU qualification versus ICU experience and knowledge of blood glucose physiology and blood glucose control in critically ill adult patients

Category	Met competence standard	Did not meet competence standard	Total
ICU qualified	38	1	38
ICU experienced (not qualified)	64	0	64

Chi-square statistics				
	Value	Asymp. Std. Error ^a	Approx. T ^b	Approx. Sig.
Interval by Interval Pearson's R	-0.129	0.065	-1.302	0.196
Ordinal by Ordinal Spearman Correlation	-0.129	0.065	-1.302	0.196
N of Valid Cases 102				

4.3.3.3 Correlation between years of experience working in an ICU and knowledge of blood glucose physiology and blood glucose control

Regression analysis was used to determine the correlation between years of experience working in an ICU and knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. The scatterplot depicted in Figure 7 below suggests that a linear correlation exists between the two variables, as the scores obtained are scattered around the line towards the positive axis. The Pearson correlation coefficient (r) is 0.28, which also suggests a positive correlation. As depicted by the scatterplot below, ICU professional nurses who had more years of experience working in an ICU appeared to be performing better than those who had less experience working in an ICU.

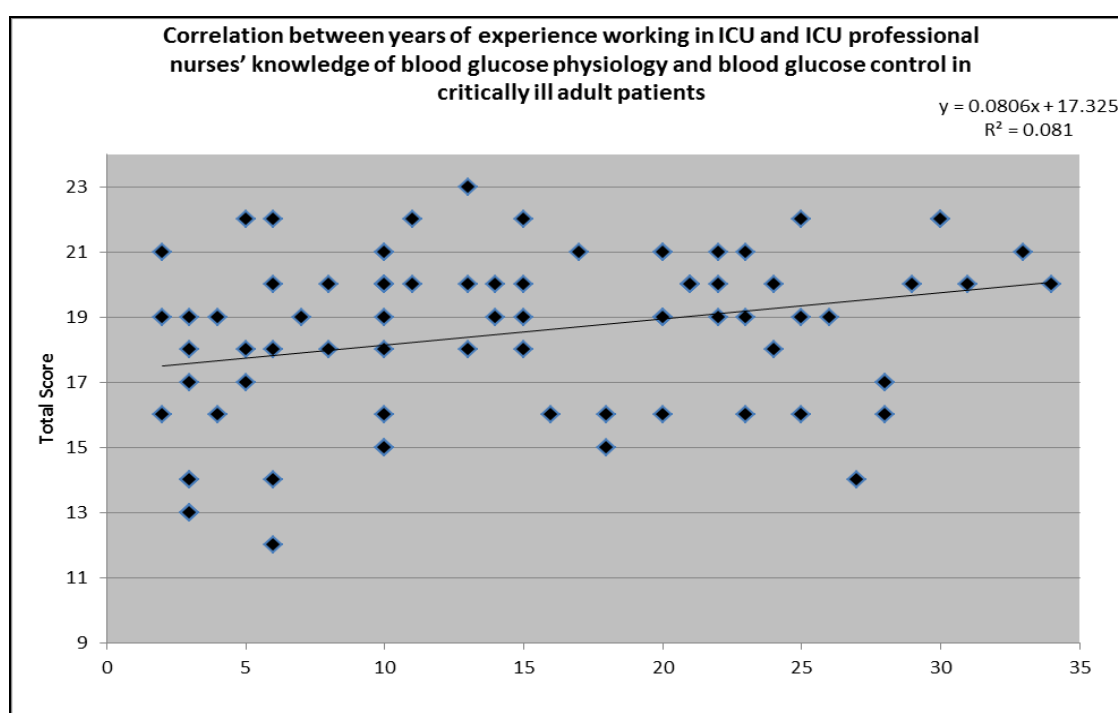


Figure 7: Correlation between years of experience working in an ICU and ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients

4.4 Summary

The demographic data show that the majority (68%) of the ICU professional nurses were in the 40-55 age range. Almost two thirds (63%) were ICU experienced but did not have an additional qualification in ICU nursing. The remaining 37% were ICU experienced and held an additional qualification in ICU nursing. Most of the ICU professional nurses (81%) ensured their continuing professional development by participating in a number of activities:

attendance at academic ward rounds, ICU congresses and critical care society meetings and reading of relevant peer reviewed journals. Their knowledge of blood glucose physiology in critically ill adult patients was found to be sufficient, as most achieved the desired 50% competency level. Similarly, knowledge of blood glucose control in critically ill patients was also sufficient, as the majority of the ICU professional nurses achieved the 60% competency level.

The Pearson correlation coefficient (r) of 0.28 identified a weak relationship between age and knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. The results also revealed a weak correlation between the knowledge of an ICU qualified versus an ICU experienced professional nurse, which suggests that being ICU qualified was not necessarily an advantage in this study. In contrast, a positive correlation was found between years of experience working in an ICU and knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. This suggests that ICU professional nurses who had more years of experience working in an ICU tended to have more knowledge of blood glucose physiology and blood glucose control than those with fewer years of experience working in an ICU.

CHAPTER 5: DISCUSSION

5.1 Introduction

This chapter discusses the main research findings and relates them to the relevant literature.

The aim of the study was to determine ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province. The objectives of the study were:

- To design and validate an instrument to determine ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province;
- To quantify and describe ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province;
- To determine if there is any correlation between age, ICU qualification versus ICU experience and years of experience working in ICU and ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients, in a public tertiary hospital in the Western Cape Province.

5.2 Demographic data

5.2.1 Age analysis

The study findings indicate that the majority of the ICU professional nurses (68%) were between the ages of 40-55 years, while 32% were younger (30-39 years). This finding indicates an ageing ICU professional nurse population. This study result is consistent with the research findings reported by Pillinger (2011:11). Professional nurses who retire will leave a significant knowledge and workforce gap in the health system, unless sufficient numbers of younger nurses enter the profession (George, Quinlan & Reardon, 2009:3).

5.2.2 Years of experience working as a general professional nurse

In this study, it was found that the majority (77.4%) of the ICU professional nurses had ten to 30 years of experience working as a general professional nurse (not ICU nursing experience). This suggest that many professional nurses gain experience in general ward

settings before entering the ICU environment, which may explain the high number of ICU professional nurses reported in this study who are not ICU qualified.

5.2.3 ICU qualification versus ICU experience

In this study, 64 (62.7%) ICU professional nurses had received no formal ICU training (they were merely ICU experienced) and 38 (37.3%) were ICU qualified. The ICU qualified professional nurse figures are slightly higher than the 25.6% reported in a 2007 national audit by Scribante and Bhagwanjee (2007:1316); however, Scribante and Bhagwanjee's audit included all ICU professional nurses, while this study excluded ICU professional nurses from the paediatric, neonatal and obstetric ICUs. The discrepancy between the numbers of ICU qualified professional nurses versus ICU experienced professional nurses could be attributed to the fact that 77% of the ICU professional nurses had more years of experience in general ward nursing. This implies that many had worked as general ward professional nurses before they moved to ICU nursing.

Nurses face a number of barriers with regard to further education and training, once they have obtained a professional qualification. These include family and child care responsibilities, staff shortages in the work environment, a lack of funding, and difficulty in obtaining study leave from the employer (Richards & Potgieter, 2010:44-45). As a result, the number of unqualified ICU professional nurses working in the ICU environment has increased (Bateman, 2009:568). The shortage of qualified ICU professional nurses is forcing unqualified ICU experienced professional nurses to take charge of the complex health care needs of critically ill patients. This practice often leads to patient care errors, which may negatively influence patient outcomes (Bateman, 2009:568). Hospitals that employ nurses with specialised training reported lower mortality and failure to rescue rates in surgical units, fewer adverse events, such as patient falls, medication errors and nosocomial or hospital acquired infections (Kendall-Gallagher & Blegen, 2009:108-109).

5.2.4 Years of experience working in an ICU

Most of the ICU professional nurses (51.9%) had four or less years of experience working in an ICU, and slightly less than half (49%) had ten to 30 years of experience. This finding indicates a relatively inexperienced ICU nursing complement (McHugh & Lake, 2010:279). The limited number of years of experience working in an ICU was also reported in a national audit, which found that a large proportion of ICU professional nurses had less than five years of experience working in an ICU (Scribante and Bhagwanjee, 2007:1316). The implications are that critically ill patients are being cared for by a high proportion of inexperienced

nurses, which could lead to patient care errors and increased morbidity and mortality (Nel, Muller & Colyn, 2011:1). Patient safety is threatened when nursing care is provided by less experienced and incompetent nursing staff (Kendall-Gallagher & Blegen, 2009:108). In contrast, patient outcomes are improved when they are cared for by nurses who have accumulated years of meaningful experience (Bobay, Gentile & Hagle, 2009:51).

5.3 Knowledge level of ICU professional nurses

This section addresses the second objective of the study, which was to quantify and describe ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

5.3.1 Knowledge of blood glucose physiology

Nine multiple choice questions in the relevant section of the questionnaire set out to determine their knowledge of blood glucose physiology in critically ill adult patients. The competency level was set at 50%, as agreed with the statistician. A score of 50-59% indicated adequate knowledge, scores between 60-69% indicated above average knowledge and scores above 70% were an indication of excellent knowledge. Any score below 50% was an indication of inadequate knowledge. A brief discussion of each question follows below.

Q1: Where in the body is insulin produced?

The correct option for this question was the pancreas, which was chosen by all the ICU professional nurses. Insulin is produced in minute quantities by the Islets of Langerhans situated within the pancreas (Hinkle & Cheever, 2014:1390). The result obtained reflects concrete knowledge of basic physiology.

Q2: What is the function of insulin in the body?

The answer to this question was that insulin is responsible for the transportation of glucose across the cell membrane into the tissues. Without insulin, blood glucose is unable to move from the blood into the tissues, and as a result hyperglycaemia occurs (Hinkle & Cheever, 2014:1390). Insulin has been identified as the preferred medication to manage and prevent hyperglycaemia in most critically ill patients, as its use is associated with reduced morbidity and mortality (Jacobi et al., 2012:3253). This option was correctly selected by 73 (72.3%) of the ICU professional nurses, signifying adequate knowledge of basic physiology. This finding is consistent with that reported by Perrie (2006:90).

Even though the majority of the ICU professional nurses demonstrated adequate knowledge of the function of insulin in the body, of concern is that almost a third (28%) lacked such

knowledge. The implication of this finding is that ICU professional nurses who do not understand the function of insulin in the body will not appreciate the blood glucose lowering value of this medication for critically ill patients. The risk is that hyperglycaemic patients may go untreated for prolonged periods and as a result suffer the harmful effects of hyperglycaemia.

Q3: What is the function of glucose in the body?

The correct response to this question is that glucose provides all living cells with life-sustaining energy (Hinkle & Cheever, 2014:81). The majority (70.6%) of ICU professional nurses answered correctly, confirming an adequate knowledge of basic physiology; however, 28% showed a lack of knowledge of essential physiology.

Q4: What is the normal blood glucose level in the body?

The normal blood glucose level ranges between 3.9 mmol/l to 5.6 mmol/l (Urden, Stacy & Lough, 2012:480). The majority of the ICU professional nurses, 72 (70.6%) answered this question correctly, thus demonstrating concrete knowledge of essential physiology. This result is in keeping with that reported by Perrie (2006:90). In Perrie's study, 100 (73.53%) ICU professional nurses out of 136 correctly indicated the normal blood glucose level in the body. Thirty ICU professional nurses in this study (29.4%) answered incorrectly, however, selecting a blood glucose range of 8 mmol/l to 10 mmol/l as normal. This implies a knowledge deficit of essential physiology, which may pose a risk in that the nurse may not recognise hyperglycaemia in the critically ill patient. Prolonged periods of hyperglycaemia are harmful and may lead to morbidity and mortality in critically ill patients (Falciglia et al., 2009:3001).

Q5: Blood glucose level less than 4 mmol/l is known as?

Hypoglycaemia is present when the blood glucose level falls to below 3.9 mmol/l; severe hypoglycaemia is regarded as a blood glucose level less than 2.5 mmol/l (Urden, Stacy & Lough, 2012:473). The majority 84 (82.4%) of ICU professional nurses were correctly able to identify hypoglycaemia, which indicates an ability to interpret abnormal blood glucose results accurately. It is essential that ICU professional nurses are able to do this to identify hypoglycaemia early and prevent harm to the patient (Turner, 2007:27). Unrecognised hypoglycaemia is harmful and may lead to irreversible brain damage or even death (Urden, Stacy & Lough, 2012:473). This study finding is in contrast with the results of a study by Chinnasamy et al (2011:315) in London, who reported that only 58 (58%) out of 100 ICU professional nurses in their study considered a blood glucose level less than 4 mmol/l to be hypoglycaemia.

Q6: Blood glucose level greater than 8 mmol/l is known as?

The correct response to this question was hyperglycaemia. Hinkle and Cheever (2014:1420) define hyperglycaemia as a blood glucose level above 7 mmol/l. The majority of the ICU professional nurses 97 (95.1%) accurately selected this option, thus indicating that they had sufficient knowledge of the essential physiology pertaining to this condition.

Q7: Hyperglycaemia in critically ill patients is usually due to?

The correct answer to select was the hyper-metabolic stress response to critical illness, surgery or trauma. Critically ill patients go through a catabolic state, whereby protein and fats are broken down to release glucose; however, in the absence of insulin, the glucose is not absorbed and thus accumulates in the blood (Donahey and Folse, 2013:1). At the same time, gluconeogenesis (formation of glucose from non-carbohydrate sources) is enhanced in the liver, which increases blood glucose levels further (Hinkle & Cheever, 2014:77). Ninety-eight (97.0%) ICU professional nurses answered this question correctly.

Q8: What other factors may contribute to the development of hyperglycaemia in critically ill patients?

The administration of glucose containing intravenous fluids, enteral feeds, inotropic medications, corticosteroid therapy and total parenteral nutrition is known to contribute to the development of hyperglycaemia in critically ill patients (Donahey & Folse, 2013:1; Kessler, 2009:38-39). It is standard practice in this research setting to commence intravenous insulin therapy for all critically ill patients receiving total parenteral and enteral nutrition, inotropic support and those on dextrose containing fluids to prevent hyperglycaemia. This could explain why 95 (94.1%) ICU professional nurses answered this question correctly.

Q9: Which of the following drugs, if administered, may contribute to the development of hyperglycaemia in critically ill patients?

The correct option here was adrenaline. The administration of inotropic medication such as adrenaline enhances gluconeogenesis in the liver, resulting in hyperglycaemia and glucose toxicity (Donahey & Folse, 2013:1; Kessler, 2009:39). Ninety-four (92.2%) ICU professional nurses selected the correct answer, demonstrating adequate knowledge of the factors that contribute to hyperglycaemia in critically ill patients. Perrie (2006:90), in contrast, reported that only 55.8% of ICU professional nurses in her study had sufficient knowledge of the role of adrenaline in the development of hyperglycaemia.

5.3.2 Knowledge of blood glucose control

In this section of the questionnaire, 14 multiple choice questions tested the respondents' knowledge of blood glucose control in critically ill patients. The competency level was set at 60%. A score of 60-69% indicated adequate knowledge and scores above 70% were an indication of excellent knowledge. Any score below 60% was considered inadequate.

Q10: Uncontrolled hyperglycaemia in critically ill patients is associated with an increased risk for morbidity and mortality.

In this true or false question, the correct option to select was 'true'. Uncontrolled hyperglycaemia in critically ill patients is associated with complications such as sepsis; poor wound healing and kidney failure (Corathers & Falciglia, 2011:276). Complications may lead to multiple organ failure, increased morbidity and death (Corathers & Falciglia, 2011:276; Valentine & Phillips, 2012:333). The prolonged state of glucose toxicity and insulin resistance contributes to micro and macro vascular complications, which in turn lead to tissue hypoperfusion and subsequent multiple organ failure (Kessler, 2009:39). This statement was correctly answered by 69 (67.6%) of the ICU professional nurses; worryingly, however, 33 (32.4%) answered incorrectly. A lack of knowledge of the dangers of hyperglycaemia exposes critically ill patients to prolonged periods of untreated hyperglycaemia, which gives rise to numerous complications as stated above. Intensive care professional nurses should be aware that even short periods of uncontrolled hyperglycaemia are independently associated with increased ICU mortality (Falciglia et al., 2009:3006).

Q11: Intravenous insulin therapy is an effective way of controlling blood glucose in critically ill patients.

Intravenous insulin therapy has been identified as the preferred method for blood glucose control in all unstable critically ill patients (McDonnell & Umpierrez, 2012:187). Ninety-two percent of the respondents chose the correct answer, i.e. 'true'. The blood glucose lowering effect of intravenous insulin therapy is fairly rapid and allows for easy titration in response to the changing insulin requirements of critically ill patients (Zantidis, Iliadis & Didangelos, 2011:80). According to McDonnell and Umpierrez (2012:187), the use of subcutaneous insulin for blood glucose control in critically ill patients should be avoided, as this practice has not been fully investigated. Subcutaneous insulin is reserved for stable patients with lower insulin requirements (Jacobi et al., 2012:3266). Blood glucose control with intravenous insulin therapy is standard practice in the particular research setting; this may explain why the majority of the respondents performed well in answering this question.

Q12: Blood glucose control using intravenous insulin therapy is associated with improved clinical outcomes for critically ill patients.

Intravenous insulin therapy for blood glucose control is associated with numerous benefits for critically ill patients. Van den Berghe et al (2001:1359-1366; 2006:455-456) reported a 42% reduction in mortality among surgical patients and a significant reduction in morbidity among critically ill medical patients, following the institution of intravenous insulin therapy for blood glucose control. Patients who received intravenous insulin therapy had lower incidences of septicaemia and acute kidney injury and a reduced need for prolonged mechanical ventilation (Gunst & van den Berghe, 2010:157-158). Ninety-eight percent of the respondents knew about the benefits of blood glucose control in critically ill patients.

Q13: Maintaining blood glucose levels in the lower ranges of 4.1 mmol/l to 6.1 mmol/l with intravenous insulin therapy is associated with reduced morbidity and mortality rates for critically ill patients.

Van den Berghe et al (2001:1361) reported a considerable reduction in morbidity and mortality rates (42%) among surgical patients whose blood glucose levels were kept within the normal level of 4.1 mmol/l to 6.1 mmol/l, by means of insulin therapy. These investigators revealed that maintaining blood glucose levels within normal limits resulted in a reduction in the length of stay within ICU, reduced the incidence of sepsis and shortened the need for prolonged mechanical ventilation and haemodialysis. Ninety-three (91.2%) ICU professional nurses had adequate knowledge of the importance of maintaining blood glucose levels within the normal range. Kok (2012:96) maintains that it is essential for all ICU professional nurses to be aware of the importance of maintaining near normal blood glucose levels in critically ill patients to ensure patient safety and improve outcomes.

Concerns have been raised by other researchers about the possibility of severe hypoglycaemia with the blood glucose target levels proposed by Van den Berghe et al (2001, 2006); however, there is general agreement that blood glucose levels greater than 8.3 to 10 mmol/l should trigger the initiation of insulin therapy for most ICU patients (Dellinger et al., 2013:193; Jacobi et al., 2012:3257).

Q14: Hypoglycaemia is a serious and life-threatening complication of insulin therapy.

The correct option ('true') was selected by 98 (97.0%) of respondents. Vincent et al (2011:69) and Moghissi (2010:5) state that hypoglycaemia is an undesired and life-threatening complication of insulin therapy. Untreated hypoglycaemia is harmful and may result in severe neurological impairment, irreversible brain injury and even death (Jacobi et al., 2012:3259; Krinsley et al., 2013:13). In view of the adverse effects associated with the use of insulin, it is essential that all ICU professional nurses possess adequate knowledge of

the side effects of this medication in order to prevent harm to critically ill patients (Lu et al., 2013:25).

Q15: Which of the following statements is correct regarding the management of hypoglycaemia in a patient who is on an insulin infusion?

The correct option for this question was to stop the insulin infusion and administer 25 to 50 ml of 50% dextrose water intravenously. Swift management of hypoglycaemia is essential, as the risk of irreversible brain damage and death is increased even with brief periods of uncorrected hypoglycaemia (Jacobi et al., 2012:3257). Guidelines published by Jacobi et al (2012:3251-3275) recommend that the insulin infusion be stopped immediately and hypoglycaemia corrected with the intravenous administration of a rapid acting carbohydrate in the form of 50% dextrose water. One hundred (99.0%) ICU professional nurses agreed that this was the correct option, indicating that this principle was well understood. The blood glucose control protocol used in the study setting is very explicit on the management of hypoglycaemia in critically ill patients, and this may explain why most ICU professional nurses knew the correct protocol to follow.

In contrast, Trepp et al (2010:372) identified a lack of knowledge among health care professionals with regard to the management of hypoglycaemia; in their study, only 25% of 232 nurses were able to manage hypoglycaemia correctly. The lack of knowledge on the management of hypoglycaemia was further corroborated in a study by Chinnasamy et al (2011:315) in London; this survey examined ward nurses' knowledge of inpatient hypoglycaemia management. Only 10% of the 100 nurses who participated in the survey responded that they would treat hypoglycaemia with a rapid acting carbohydrate. A lack of knowledge of the management of hyperglycaemia is a potential risk to the safety of critically ill patients. Prolonged and uncorrected hypoglycaemia is known to cause sudden cardiac arrest and irreversible brain injury, resulting in increased morbidity and mortality in critically ill patients (Jacobi et al., 2012:3257).

Q16: Clinical manifestations of hypoglycaemia in critically ill patients may include the following EXCEPT...

The clinical manifestations of hypoglycaemia include sweating, tremor, tachycardia, nervousness, hunger, headache, confusion, and dizziness. Other clinical manifestations include slurred speech, disorientation, seizures and loss of consciousness (Hinkle & Cheever, 2014:1441-1442). Reduced urine output was the exception and had to be excluded as the answer to this question. Eighty-three (81.4%) ICU professional nurses did not know which option to exclude as a clinical manifestation of hypoglycaemia in critically ill patients. Only 19 (18.6%) ICU professional nurses were correct in selecting to 'exclude decreased urine

output'. The result suggests that the ICU professional nurses are unable to identify the clinical manifestations of hypoglycaemia in critically ill patients. This finding is consistent with that reported by Chinnasamy et al (2011:315). The risk is that critically ill patients may develop hypoglycaemia and go unnoticed for prolonged periods and as a result suffer irreversible brain injury and even death (Chinnasamy et al., 2011:315).

Q17: Hypokalaemia is a potentially life-threatening complication of insulin therapy.

Hypokalaemia is defined as a serum potassium level of less than 3.5 mmol/l (Baird & Bethel, 2011:52). Insulin therapy enhances the movement of potassium into the cells and may cause subsequent hypokalaemia (Baird & Bethel, 2011:52). Decreased serum potassium is potentially life-threatening and may cause the development of life-threatening cardiac arrhythmias, such as ventricular tachycardia, ventricular fibrillation and cardiac arrest (Urden, Stacy & Lough, 2010:401; Vincent et al., 2011:57-58).

A knowledge deficit was thus identified with regard to this question, as most of the ICU professional nurses (58.9%) obtained a score of 56.9%, which is less than the set competency level of 60%. According to the Scope of Practice of professional nurses (Nursing Act, No. 33 of 2005, Regulation R2598 of 30 November 1984 (2) (c), as amended), professional nurses are responsible for the administration of medication to a patient, including monitoring the patient for adverse reactions to the medication. A lack of knowledge with regard to the side effects of high alert medications like insulin is a potential risk to patient safety and may lead to unrecognised hypokalaemia and its related complications (Lee et al., 2013:190-191). The result signifies a need for further education and training on the side effects of insulin.

Q18: Life-threatening hypokalaemia in critically ill patients is managed as follows...

Life-threatening hypokalaemia should be corrected by replacing potassium intravenously at a rate not exceeding 10 to 20 mmol/l per hour over two to four hours (Baird & Bethel, 2011:53; Vincent et al., 2011:59). This question was correctly answered by 74 (72.5%) of the ICU professional nurses. Of concern is the fact that 28 (27.5%) ICU professional nurses appeared to be less knowledgeable about the management of hypokalaemia in critically ill patients. Untreated hypokalaemia triggers lethal cardiac arrhythmias, such as ventricular fibrillation and cardiac arrest, which may cause sudden death in critically ill patients; therefore, all ICU professional nurses should possess adequate knowledge to enable them to manage this complication correctly (Urden, Stacy & Lough, 2010:401). The identified lack of knowledge may be attributed to the fact that there is no protocol available in the research setting to guide the ICU professional nurses on the management of hypokalaemia in critically ill patients.

Q19: Insulin infusions should ideally be given via a dedicated intravenous line.

Insulin should ideally be infused through a dedicated intravenous line to prevent insulin ‘back-tracking’ or drug incompatibility (Turner, 2007:28; Vygon, 2010:5). Insulin ‘back-tracking’ occurs when insulin that is infused through a single line, together with other medications, under different pressures, flows away from the intended point: for example, away from the patient (Vygon, 2010:5). This phenomenon is common when two or more medications are being administered through a single intravenous line that becomes blocked or kinked. While the line is kinked or blocked, medication that is administered under higher pressure is diverted away from the patient towards a point of lower pressure and resistance, namely, the intravenous line, syringe pump or vacoliter. This results in two problems: firstly, treatment is interrupted, as the medication that is flowing under higher pressure is diverted away from the patient to an area of less resistance. Secondly, once the blockage is removed, all the medication that has built up in the line, syringe or vacoliter will now flow to the patient and result in the administration of a rapid bolus. This could lead to a drug overdose and occasionally even death (Vygon, 2010:5).

Drug incompatibility occurs when insulin is administered together with certain incompatible medications, such as magnesium, dopamine, phenytoin and ranitidine (Cayo, 2011:5). Drug incompatibility may lead to loss of drug potency and treatment failure (Cayo, 2011:6). Ninety-three (91.2%) of the ICU professional nurses gave the correct answer to this true or false question, which demonstrates an adequate knowledge of insulin administration. It is standard practice in the particular research setting to infuse insulin via a dedicated intravenous line to prevent the administration of a rapid insulin bolus to the patient. This could explain why this question was correctly answered by the majority of the ICU professional nurses.

Q20: Insulin infusions may be given via the same line as other compatible medications.

According to Turner (2007:28) and Cayo (2011:5), insulin can only be infused together with other compatible medication to avoid the incidence of adverse drug reactions. Intravenous insulin is compatible with most antibiotics, heparin, furosemide and potassium, but it is incompatible with magnesium, phenytoin, dopamine and ranitidine (Cayo, 2011:5; Turner, 2007:28). It is important that ICU professional nurses verify drug compatibility before co-administration to prevent inadvertent life-threatening adverse effects, such as particulate formation, drug precipitation and loss of drug potency (Cayo, 2011:6). The results of this study indicate a knowledge deficit, in that 58.8% of the ICU professional nurses answered this question incorrectly. This finding has important safety implications for the patient, as the co-administration of incompatible medication can result in the formation of toxic compounds

that are harmful to the patient (Cayo, 2011:6). In addition, reduced efficacy of the active ingredient may occur, which may result in treatment failure (Cayo, 2011:6). The ICU professional nurses may have underperformed with regard to this question, because it is common practice in the research setting to infuse insulin separately from other intravenous medications.

Q21: Which carrier solution (diluent) should be used when mixing insulin infusion?

The insulin infusion may be mixed with normal saline, Ringers lactate, 5% dextrose water or haemacel (Jacobi et al., 2012:3266; Turner, 2007:28). According to Turner (2007:26), dextrose solutions are to be avoided, as this, in combination with insulin, promotes the development of hypokalaemia. The most common practice in the ICU where the study was conducted is to mix insulin with normal saline. Sixty-nine percent of the respondents answered this question correctly. This finding was unexpected, as the blood glucose control protocol used in the research setting specifies that normal saline be used to mix the insulin infusion. An implication of this finding is that inaccurate insulin mixing strategies can result in insulin adsorption and failure to manage hyperglycaemia effectively (Jacobi et al., 2012:3266).

Q22: Insulin infusions should be remixed...

Turner (2007:26) recommends that insulin infused at room temperature be remixed every 12 hours to ensure stability and to prevent the incidence of insulin adsorption. Insulin administered at room temperature for longer periods becomes unstable, which results in increased insulin adsorption into the administration set (Turner, 2007:26). The current study found that 83 (81.4%) of the ICU professional nurses lacked knowledge of how often to remix insulin, as most ICU professional nurses opted to change the insulin syringe when the infusion was completed. This finding is concerning, as effective blood glucose control depends on the delivery of adequate amounts of insulin to the patient. The implication is that the patient may be receiving less insulin than what is required to manage hyperglycaemia effectively (Turner, 2007:26).

Q23: How often should blood glucose be monitored while the patient is receiving an insulin infusion?

Recommendations by Dellinger et al (2013:193) and Jacobi et al (2012:3261) suggest that blood glucose be monitored every one to two hours in unstable critically ill patients. Frequent blood glucose monitoring is essential for the early recognition of blood glucose levels outside the desired target levels (Jacobi et al., 2012:3261). Delays in the monitoring interval are not recommended, as this practice is unsafe and may contribute to the development of hypoglycaemia (Dellinger et al., 2013:193). The correct answer to this

question ('one to two hours') was chosen by 98 (97.0%) of the ICU professional nurses, which implies adequate knowledge. This result may be explained by the fact that the blood glucose protocol used by the ICU professional nurses provides clear guidelines on the frequency of blood glucose monitoring in critically ill patients.

5.3.4 Correlation between demographic factors and knowledge of blood glucose physiology and blood glucose control

The third objective of the study was to determine any correlation between age, ICU qualification versus ICU experience, as well as years of experience working in ICU and ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

5.3.4.1 Correlation between age and knowledge of blood glucose physiology and blood glucose control

The Pearson correlation coefficient (r) of 0.3 (see Figure 6 on page 40) shows a positive but minimal correlation between age and knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. This finding is to be expected, as older nurses are generally assumed to be more experienced and therefore more knowledgeable than younger nurses (Whyte, Ward & Eccles, 2009:523). This finding differed from that reported in a similar study, which examined the relationship between age and ICU nurses' knowledge. Gomes (2010:95) found no correlation between age and ICU nurses' knowledge of evidence based guidelines for the prevention of ventilator associated pneumonia.

5.3.4.2 Correlation between ICU qualification versus ICU experience and knowledge of blood glucose physiology and blood glucose control

No significant differences were found between ICU qualified and ICU experienced professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients (see Table 4, page 41). This finding was unexpected, as ICU qualified professional nurses have undergone a year of specialisation training and are therefore expected to be functioning at a level much higher than their ICU experienced colleagues (Perrie et al., 2014:17). A possible explanation for this result could be that both ICU qualified and ICU experienced professional nurses is exposed to the weekly in-service training on blood glucose control in critically ill patients. This finding is consistent with that of Gomes (2010:96) who found no significant difference between ICU qualified and non-ICU qualified nurses' knowledge of evidence based guidelines for the prevention of

ventilator associated pneumonia. In contrast, Perrie et al (2014:17) reported a significant 5.1% difference ($p=0.0099$) between ICU qualified and non ICU qualified nurses' knowledge of pain management, glycaemic control and weaning the critically ill patient from mechanical ventilation.

5.3.4.3 Correlation between years of experience working in an ICU and knowledge of blood glucose physiology and blood glucose control

A correlation coefficient (r) of 0.28 was found, which suggests a positive correlation between years of experience working in an ICU and knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. The results imply that ICU professional nurses who worked longer in an ICU had more knowledge of blood glucose physiology and blood glucose control in critically ill adult patients than their less experienced colleagues. The result may also imply that the ICU professional nurses in this study have continued to develop or educate themselves over the years while working in an ICU.

This finding is consistent with the results reported by Jansson et al (2013:219) who, in a survey investigating critical care nurses' knowledge of, adherence to and barriers towards evidence based guidelines for the prevention of ventilator associated pneumonia, reported that the more experienced ICU nurses performed significantly better than their less experienced colleagues. The significance of this finding is that patient care outcomes are improved in situations, where they are cared for by nurses who have accumulated years of meaningful experience (Bobay, Gentile and Hagle, 2009:51-52).

Contrary to the results reported in this study, Gomes (2010:96) and Perrie et al (2014:16) identified a weak correlation between ICU nurses' knowledge and years of experience working in an ICU.

5.4 Summary

The ICU professional nurses who participated in this study demonstrated that they had adequate knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. Data analysis revealed that the majority achieved the desired competency levels of 50% and 60% respectively, on questions investigating knowledge of blood glucose physiology and blood glucose control in critically ill adult patients. A positive but minimal correlation was found between the respondents' age as well as their years of experience working in an ICU and knowledge of blood glucose physiology and blood glucose control in

critically ill adult patients. No significant difference was found between ICU qualified and ICU experienced professional nurses in this regard.

The ICU professional nurses may have performed well because blood glucose control is a topic frequently discussed in the ICUs, in which the study was conducted. The ICU Mentor presents regular weekly in-service training sessions on various topics, including blood glucose control in critically ill patients. The adequate knowledge demonstrated by the ICU professional nurses could also be attributed to the fact that they ensure their own continuing professional development by attending academic ward rounds and critical care society meetings, where blood glucose control in critically ill patients is discussed.

Whilst the ICU professional nurses demonstrated adequate knowledge of blood glucose physiology and blood glucose control in critically ill adult patients, they demonstrated a lack of knowledge with regard to some of the questions (Q16, Q17, Q20, and Q22). Eighty-three (81.4%) ICU professional nurses did not know which option to exclude from the clinical manifestations of hypoglycaemia in critically ill patients (Q16). A lack of knowledge was also found with regard to the mixing of insulin infusions, as the number of correct responses to this question was below the set competency level of 60% (Q17). In addition, 60 (58.8%) ICU professional nurses were not aware that insulin may be infused via the same line with other compatible medications.

Finally, 83 (81.4%) ICU professional nurses failed to note that hypokalaemia was a life-threatening side effect of insulin therapy (Q22). This knowledge deficit is of concern, as it poses a risk to patient safety and may hamper the attainment of improved outcomes for critically ill adult patients.

CHAPTER 6: RECOMMENDATIONS, LIMITATIONS AND CONCLUSION

The following recommendations, as derived from the study findings, are made relating to nursing management, education and research. Thereafter, two limitations are mentioned, and final conclusions are presented.

6.1 Nursing management

- The human resource development planning for the ICUs in this study setting should take into account the aging nurse complement, and appropriate recruitment strategies should be implemented.
- Education opportunities with appropriate financial support should be provided for ICU experienced professional nurses for them to be able to study further and become ICU qualified.
- A guiding protocol should be developed to manage hypokalaemia in critically ill patients.
- In-service training should focus on improving knowledge in the following areas:
 - The function of insulin in the body.
 - The function of glucose in the body.
 - The normal blood glucose levels in the body.
 - The risks of uncontrolled hyperglycaemia in critically ill patients.
 - The clinical manifestations of hypoglycaemia in critically ill patients.
 - The adverse effects of intravenous insulin therapy.
 - The management of hypokalaemia in critically ill patients.
 - Insulin compatibility with intravenous medication.
 - Mixing of insulin infusions.
- A post in-service training survey should be conducted to determine improvement in knowledge.

6.2 Nursing education

- The ICU Mentor should regularly evaluate ICU professional nurses' knowledge of routine ICU practices to identify learning deficits and implement remedial action as soon as possible.
- Continuing professional development programs should be made available to all ICU professional nurses to keep their knowledge up to date.

6.3 Nursing research

- Future research should be conducted to compare ICU qualified and ICU experienced professional nurses' knowledge of blood glucose control in critically ill patients. This could be done at the various public tertiary or private hospitals in South Africa.
- Future studies should investigate ICU enrolled nurses' knowledge of blood glucose physiology and blood glucose control, as they are also responsible for blood glucose monitoring in critically ill patients.
- Future studies should investigate professional and enrolled nurses' knowledge of blood glucose control in the paediatric department and in the general wards.

6.4 Limitations

- The study was limited to one public tertiary hospital in the Western Cape Province, therefore the findings cannot be generalised to other hospitals.
- Although the data collection instrument was assessed as content valid by an expert panel group, reliability may be lacking, as the Cronbach alpha coefficient was not demonstrated.

6.5 Conclusion

The aim of this study was to determine ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province. Based on the study results, it can be concluded that their knowledge in this regard was indeed adequate. The study has shown that older ICU professional nurses with many years of experience working in an ICU were more knowledgeable about blood glucose physiology and blood glucose control in critically ill

adult patients. This finding was expected, as older and experienced nurses are expected to have better knowledge than younger and less experienced nurses.

The study found no significant difference in the knowledge levels between ICU qualified and ICU experienced (not ICU qualified) professional nurses. This finding was unexpected, as ICU qualified professional nurses have undergone a full year of specialisation training and are thus expected to be more knowledgeable than their ICU experienced colleagues.

The results of this study show that both ICU qualified and ICU experienced professional nurses had adequate knowledge of blood physiology and blood glucose control in critically ill adult patients. This study does not, however, evaluate the practice of ICU professional nurses with respect to the management of blood glucose in critically ill patients. Knowledge and practice cannot be assumed to be consequent, and a study that evaluates if such knowledge is translated into practice would be an important consideration in the future.

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Appendix A: Participant information sheet

Dear nursing colleague

My name is Monwabisi Charles Mesela, I am a student studying towards a Masters Degree in Nursing (MSc Nursing) at the Faculty of Health Sciences, University of Cape Town (UCT). I hereby wish to invite you to participate, on a voluntary basis in the proposed research study. The study forms part of the course requirements for MSc Nursing at UCT. Please take your time and read the information provided on the research study. Forward any queries regarding this research study to the address indicated at the end of this letter.

Thanking you in advance for your assistance.

Title of the research study

Survey into ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province

Purpose of the study

The research will be done for educational purposes and to add data to the literature on ICU professional nurses' knowledge on blood glucose physiology and blood glucose control in critically ill patients in the Western Cape Province.

Your role in the study

You will be requested to complete an anonymous questionnaire while on duty and hand it back in a sealed envelope to the researcher. You have been chosen as a participant as you meet our inclusion criteria which is being a professional nurse working in an ICU.

Benefits and costs

As a research participant you will not benefit directly from the study. However your input may provide valuable information that may be used for educational purposes. There is no cost associated with taking part in the study. You will not be requested to pay any fee for participating in the study and you will also not be receiving any financial stipends for taking part in the research study.

Associated risks of participating

We foresee no risks to you for participating in this study. Anonymity will be ensured as your name and personal details will not appear on the questionnaire. Not even the researcher will know who provided the answers to the questions posed in the questionnaire. Confidentiality will be adhered to as your name and details will not be revealed in the study and during

publication of the study results. As a participant you retain the right to withdraw from the study at any time without incurring any penalties.

The researcher, the statistician and the supervisor will be the only people having access to the data. The research data will be kept in the researchers' office for at least two years after publication, in a lockable filing cabinet. The collected data will be destroyed by the researcher after publication.

Questions

Should you have any further questions regarding the study please don't hesitate to call me or the supervisor on the following contact details. The Head of the Ethics committee at UCT may also be approached for further information on the research study.

Main Researcher: Mr MC Mesela

Student number: MSLMON002

Degree programme: MSc Nursing

Western Cape College of Nursing

Private Bag 556

Surwell

Klipfontein Road

Athlone, 7762

Cell phone: 0732095293

Work telephone: 021-6841316

Fax no. 021-6371317

E-mail: mcmesela@pgwc.gov.za

My supervisor's contact details

Ms Nicki Fouche'

Division of Nursing & Midwifery

Department Health and Rehabilitation Sciences.

Faculty of Health Sciences

University of Cape Town

Observatory 7925

Tel: 021: 406 6672

Email: Nicki.Fouche@uct.ac.za

Contact details of the UCT Health Sciences Faculty Human Research Ethics Committee

Room E-52-24 Groote Schuur Hospital Old Main Building

Observatory

Tel: 021 4066338

Declaration by participant

I.....

... agree to participate in this research study entitled:

Survey into ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

I hereby declare that:

I have read and understand the information about this research study as explained on the participant information sheet and have no further questions in this regard.

I have been told that participation in this study is voluntary and that I may withdraw at any time should I wish to do so without incurring any penalties or sanctions.

Signed at.....on.....2012

Declaration by Researcher

I, Monwabisi Charles Mesela, declare that:

I provided and explained information regarding the research study to the participant indicated above.

I am satisfied that the participant fully understands the rationale of the study and willingly chose to participate.

SignedDate..... 2012.

Appendix B: Record of informed consent

Title of the research study:

Survey into ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

Researcher: Mr MC Mesela

Western Cape College of Nursing

Private Bag 556 Surwell

Klipfontein Road, Athlone, 7762

Cell phone: 0732095293 Work telephone: 021-6841316 Fax no. 021-6371317

E-mail: mcmesela@pgwc.gov.za

My supervisor's contact details

Ms Nicki Fouche'

Division of Nursing & Midwifery

Department of Health and Rehabilitation Sciences.

Faculty of Health Sciences

University of Cape Town, Observatory 7925

Tel: 021: 406 6672

Email: Nicki.Fouche@uct.ac.za

I have read the information about the research study and agree to participate voluntarily. I fully understand the information given to me regarding this study and had the opportunity to ask questions which were answered to my satisfaction. I understand that my identity will not be disclosed and that I may withdraw from the study without giving reason at any time and this will not negatively affect me in any way. I hereby give my consent freely and without any reservations.

Participant name and surname:.....

Participant's signature:.....Date

Researcher's name and surname:.....

Researcher signature:..... Date

Appendix C: Request to collect data at research setting

Western Cape College of Nursing
Klipfontein Road
Private Bag 556
Surwell
Klipfontein Road
Athlone, 7762
September 2012.

The Nurse Manager
Groote Schuur Hospital
Anzio road
Observatory
Cape Town
7935

Dear Mrs Ross

RE: Data collection for Master's Dissertation at Groote Schuur Hospital

I am currently completing my Master's Degree in Nursing at the University of Cape Town. The focus of my dissertation is on ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in the critically ill adult patient. The purpose of the study is educational. Data will be collected through a questionnaire which will be completed during the staff in-service time slot. The questionnaire will take 15 to 30 minutes to complete and will be distributed to all ICU professional nurses who are on duty. The results of the study will be made known to all the relevant parties including the Medical and Nursing staff in the ICU.

Kindly forward your response to the main researcher email address.

Yours sincerely

Monwabisi Charles Mesela
MSc Nursing Student
University of Cape Town
mcmesela@westerncape.gov.za
021 684 1316
Ethics clearance approval No.....

Supervisor:
Ms.N.Fouche'
Senior Lecturer
Department of Health & Rehabilitation Sciences.
Faculty of Health Sciences
Division of Nursing & Midwifery
University of Cape Town
Observatory
7925
Tel: 021: 406 6672
Email: Nicki.Fouche@uct.ac.za

Appendix D: Permission to conduct research: Groote Schuur Hospital

Western Cape College of Nursing
Klipfontein Road
Private Bag 556
Surwell
Athlone, 7762
September 2012

The Chairperson
Human Research Ethics Committee
Department of Health
Groote Schuur Hospital
Private bag X 4
Anzio road, Observatory
7925

Dear Dr Patel

RE: PERMISSION TO CONDUCT RESEARCH AT GROOTE SCHUUR HOSPITAL

I am currently a final year MSc Nursing student at the University of Cape Town. My research study focuses on ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill patients. The purpose of the study is educational.

I hereby request permission to conduct the study in the Medical and Surgical ICU at Groote Schuur Hospital. Data collection, through a questionnaire, is proposed to start in October 2012 during the in-service time period. The questionnaire will take 15 to 30 minutes to complete and will be distributed to all ICU professional nurses who are on duty.

Arrangements to enter the ICU will be made with the Area Managers, Operational Nurse Managers and ICU Mentor to ensure that patient care is not disrupted.

Ethical clearance for this study was granted by the Ethics Committee of the University of Cape Town (Ethics clearance no.....). Informed consent will be asked from each participating ICU professional nurse. Information pertaining to the study will be made available to all of the ICU professional nurses. The participant's ethical rights as mandated in the declaration of Helsinki (2008) will be honoured and ensured throughout the study.

Attached please find information pertaining to the study including the consent form for the ICU professional nurses.

Please forward your response to the main researcher email address.

Yours Sincerely

Monwabisi Charles Mesela

University of Cape Town

mcmesela@westerncape.gov.za

021 684 1316

Ethics clearance certificate No.....

Supervisor: Ms N.Fouche'

Senior Lecturer

Department of Health & Rehabilitation Sciences.

Division of Nursing & Midwifery

University of Cape Town

Tel: 021: 406 6672

Email: Nicki.Fouche@uct.ac.za

Appendix E: Expert panel information letter and consent form regarding the validation of the data collection instrument

Expert code number.....

Researcher: Mr MC Mesela

Western Cape College of Nursing

Private Bag 556

Surwell, 7762

Klipfontein road

Athlone

Cell phone: 0732095293

Work telephone: 021-6841316

E-MAIL: mcmesela@pgwc.gov.za

Fax no. 021-6371317

Title of the study: Survey into ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

Dear expert panel member.

I am currently a final year MSc Nursing student at the University of Cape Town. I hereby request you to be part of an expert panel to validate the data collection instrument to be used for the proposed study (Appendix G). As a member of the expert panel, you will be required to establish the content validity for each question using a four point ordinal scale. The following is an example of the rating scale to use when assessing content validity:

1= Irrelevant

2 = Relevant but unimportant

3 = Relevant and important

4 = relevant and very important

Additions and omissions must be indicated in the space provided at the end of each item.

For the evaluation of construct validity, a checklist containing the following items will be used: layout, format, quality, clarity of questions, length of questionnaire, visually easy to read and comprehend, realistic completion time, and relevance of questions to the literature

and scope of practice for a professional nurse. You will be requested to indicate your view by making an X under the appropriate column.

Participation is voluntary. You will not benefit directly by participating as an expert panel member but the study results may assist you in designing appropriate educational programs on blood glucose control in the critically ill. Please email or post the completed checklist to the researcher to the address indicated above.

CONSENT FORM: EXPERT PANEL MEMBER

I _____ fully understand and agree to the contents of the information letter. I understand that I may withdraw from being a member of the expert panel group without any penalty. I hereby give my consent to participate as a member of the expert panel group freely and without any reservations.

Signature panel member..... Date.....

Appendix F: Expert opinion on the content validity index (CVI) of each item of the questionnaire

Rating scale to be used

1 = Irrelevant

2 = Relevant but unimportant

3 = Relevant and important

4 = Relevant and very important

Please indicate your choice with an X

THE QUESTIONNAIRE

QUESTION	1	2	3	4
Q. 1				
Q. 2				
Q. 3				
Q. 4				
Q. 5				
Q. 6				
Q. 7				
Q. 8				
Q. 9				
Q. 10				
Q. 11				
Q. 12				
Q. 13				
Q. 14				
Q. 15				
Q. 16				
Q. 17				

Q. 18				
Q. 19				
Q. 20				
Q. 21				
Q. 22				
Q. 23				

Comments

DEMOGRAPHICS

Rating scale to be used

1 = Irrelevant

2 = Relevant but unimportant

3 = Relevant and important

4 = Relevant and very important

Please indicate your choice with an X

QUESTION	1	2	3	4
Q. 1				
Q. 2				
Q. 3				
Q. 4				
Q. 5				
Q. 6				

Comments

Please indicate your view for each item by making an X under the appropriate column.

Item	Very skilful	Satisfactory	Need improvement	Unacceptable
Layout				
Format				
Quality of printing				
Easy to read				
Easy to understand				
Completion time				
Length of questionnaire				
The use of multiple choice questions				

Comments

Appendix G: The questionnaire

Title: Survey into ICU professional nurses' knowledge of blood glucose physiology and blood glucose control in critically ill adult patients in a public tertiary hospital in the Western Cape Province.

- This questionnaire is anonymous.
- **Please do not write your name.**
- Please answer the following questions and mark the appropriate box with an X

Section 1: Demographics

1. Age?
2. Are you ICU qualified or experienced?

Trained	
Experienced	
Both	

3. How many years of experience do you have working in an ICU?.....
4. How many years do you have working as a nurse?.....
5. How do you ensure your own continuing personal growth?

Attend ICU congress	
Read peer reviewed journals	
Attend academic ward rounds	
Attend critical care society meetings	
None	

Section 2: Instructions to complete the questionnaire
Make a circle around the most correct answer

1 Where in the body is insulin produced?

- (a) In the liver
- (b) In the brain
- (c) In the pancreas
- (d) In the kidney
- (e) Do not know

2. What is the function of insulin in the body?

- a) To raise the blood glucose level
- b) To facilitate glucose transport into the cells
- c) To break down fats and carbohydrates
- d) All of the above
- e) Do not know

3 What is the function of glucose in the body?

- a) To nourish the body cells
- b) To move insulin into the body cells
- c) To correct hypokalaemia
- d) To treat hyperglycaemia
- e) Do not know

4 What is the normal fasting blood glucose level in the body?

- a) < 4 mmol/l
- b) 4-6 mmol/l
- c) 7-9 mmol/l
- d) > 10 mmol/l
- e) Do not know

5 A blood glucose level less than 4 mmol/l is known as?

- a) Hyperglycaemia
- b) Hypoglycaemia
- c) Hypokalaemia
- d) None of the above
- e) Do not know

6 A blood glucose level greater than 8 mmol/l is known as?

- a) Hypokalaemia
- b) Hyperglycaemia
- c) Hypoglycaemia
- d) None of the above
- e) Do not know

7 Hyperglycaemia in critically ill patients is usually due to?

- a) A hyper metabolic stress response due to critical illness
- b) Due to prolonged periods of tissue hypo perfusion
- c) Due to treatments like insulin infusion therapy
- d) Due to prolonged periods of malnutrition
- e) Do not know

- 8 What other factors may contribute to the development of hyperglycaemia in the critically ill**
- a) Administration of enteral feeds, dextrose containing fluids, TPN and inotropes
 - b) Hypokalaemia
 - c) Poor peripheral circulation and oedema
 - d) None of the above
 - e) Do not know
- 9 Which of the following drugs, if administered, may contribute to the development of hyperglycaemia in critically ill patients?**
- a) Adrenaline
 - b) Insulin
 - c) Potassium Chloride
 - d) Potassium phosphate
 - e) Do not know
- 10 Uncontrolled hyperglycaemia in critically ill patients is associated with an increased risk for morbidity and mortality.**
- a) True
 - b) False
 - c) Do not know
- 11 Intravenous insulin therapy is an effective way of controlling blood glucose in critically ill patients.**
- a) True
 - b) False
 - c) Do not know
- 12 Blood glucose control using intravenous insulin therapy is associated with improved clinical outcomes for critically ill patients.**
- a) True
 - b) False
 - c) Do not know
- 13 Maintaining blood glucose levels in the lower ranges of 4.1 mmol/l to 6.1 mmol/l with intravenous insulin therapy is associated with reduced morbidity and mortality rates for critically ill patients.**
- a) True
 - b) False
 - c) Do not know
- 14 Hypoglycaemia is a serious and life-threatening complication of insulin therapy**
- a) True
 - b) False
 - c) Do not know
- 15 Which of the following statements is correct regarding the management of hyperglycaemia in a patient who is on an insulin infusion?**
- a) Stop insulin infusion and give 50% dextrose water intravenously
 - b) Continue insulin infusion, do not give 50% dextrose but start enteral feeds
 - c) Commence normal saline infusion to increase blood glucose levels
 - d) Continue insulin infusion and recheck blood glucose in two hours
 - e) Do not know

- 16 Clinical manifestations of hypoglycaemia in critically ill patients may include the following EXCEPT**
- a) Tachycardia, diaphoresis, confusion and seizures
 - b) Nausea and vomiting including diarrhoea
 - c) Decreased urine output
 - d) Paralytic Ileus and leg cramps
 - e) Do not know
- 17 Hypokalaemia is a potentially life-threatening complication of insulin therapy**
- a) True
 - b) False
 - c) Do not know
- 18 Life-threatening hypokalaemia in the critically ill is managed as follows**
- a) Give intravenous potassium at a rate of 20 mmol/l per hour
 - b) Give intravenous insulin as a bolus
 - c) Give intravenous potassium as a bolus
 - d) Give 50ml, 50% dextrose with 10 units of Actrapid stat
 - e) Do not know
- 19 Insulin infusions should ideally be given via a dedicated intravenous line**
- a) True
 - b) False
 - c) Do not know
- 20 Insulin infusions may be given via the same line as other compatible medications**
- a) True
 - b) False
 - c) Do not know
- 21 Which carrier solution (diluent) should be used when mixing insulin infusion**
- a) 5% Dextrose water
 - b) Rehydration solution
 - c) Isotonic saline / Haemacel
 - d) General maintenance solution
 - e) Do not know
- 22 Insulin infusions should be remixed...**
- a) Any time when the infusion is completed
 - b) Every 24 hours
 - c) Every 12 hours
 - d) When the blood glucose is stable
 - e) Do not know
- 23 How often should blood glucose be monitored while patient is receiving an insulin infusion?**
- a) 1 to 2 hourly
 - b) 4 to 6 hourly
 - c) Daily
 - d) Twice daily
 - e) Do not know

Thank you for participating in the study.

Appendix H: Testing of data collection instrument

Please complete the attached questionnaire and answer the following questions:

- (1) Is the questionnaire clearly worded?
- (2) Are the questions well explained and easy to understand?
- (3) Are the questions difficult to answer?
- (4) Are the questions easy to answer?
- (5) Are the questions at the appropriate level for an ICU professional nurse?

Comments:

(1).....

(2).....

(3).....


(4).....

(5).....

Thank you for testing the questionnaire

Appendix I: University of Cape Town ethics clearance certificate

UNIVERSITY OF CAPE TOWN



Faculty of Health Sciences
Faculty of Health Sciences Human Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • Facsimile [021] 406 6411
e-mail: sumayah.ariefdien@uct.ac.za

22 November 2012

HREC REF: 621/2012

Ms MC Mesela
c/o Ms N Fouche
School of Health & Rehab Sciences
F-45
OMB

Dear Ms Mesela

PROJECT TITLE: ICU REGISTERED NURSES KNOWLEDGE ON BLOOD GLUCOSE PHYSIOLOGY AND BLOOD GLUCOSE CONTROL IN THE CRITICALLY ILL PATIENT IN THE WESTERN CAPE PROVINCE

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee for review.

It is a pleasure to inform you that the Ethics Committee has **formally approved** the above-mentioned study.

Approval is granted for one year till the 28 November 2013.

Please submit a progress form, using the standardised Annual Report Form, if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC. REF in all your correspondence.

Yours sincerely

pp *T. Burgess*
PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

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Appendix J: Letter of permission to conduct research at Groote Schuur Hospital

GROOTE SCHUUR HOSPITAL

Enquiries: Dr Bhavna Patel

E-mail : Bhavna.Patel@westerncape.gov.za

Mr M. C. Mesela C/o Ms N. Fouche

School of Health & Rehab Sciences F45 – Old Main Building

E-mail: mcmesela@westerncape.gov.za

Dear Mr Mesela

RESEARCH: ICU Registered Nurses Knowledge on Blood Glucose Physiology and Blood Glucose Control in the Critically-ill Patient in the Western Cape Province

Your recent letter to the hospital refers.

You are hereby granted permission to proceed with your research.

Please note the following:

a) Your research may not interfere with normal patient care b) Hospital staff may not be asked to assist with the research. c) No hospital consumables and stationary may be used. d) No patient folders may be removed from the premises or be inaccessible. e) Please introduce yourself to the person in charge of an area before commencing. f) Confidentiality must be maintained at all times.

I would like to wish you every success with the project.

Yours sincerely



DR BHAVNA PATEL SENIOR MANAGER: MEDICAL SERVICES Date: 29th November 2012

C.C. Mrs M. Ross

G46 Management Suite, Old Main Building, Private Bag X, Observatory 7925 Observatory, 793

